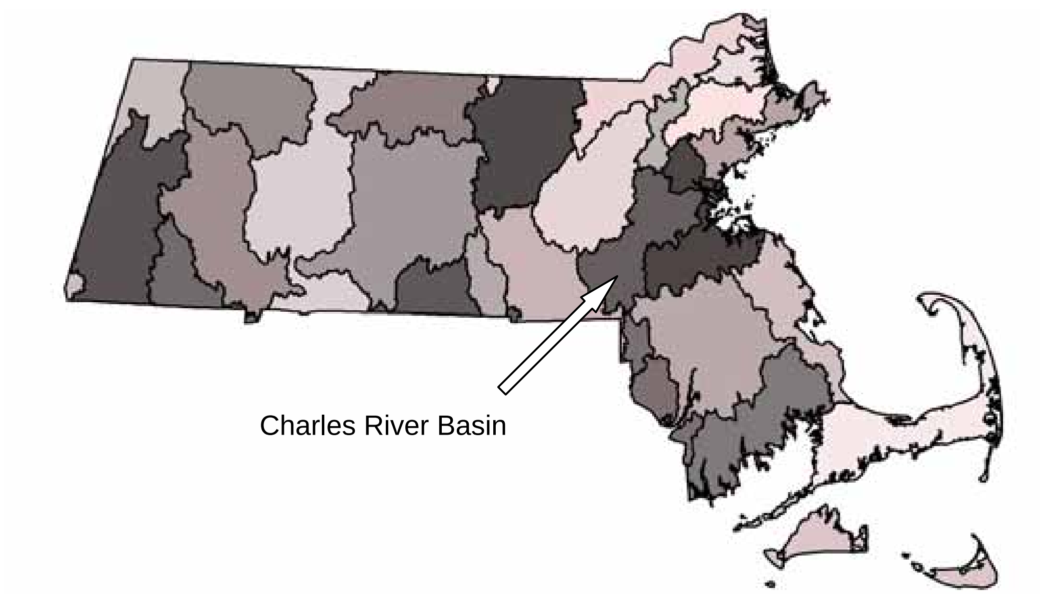
Draft Pathogen TMDL for the Charles River Watershed



Prepared as a cooperative effort by:

Massachusetts DEP
1 Winter Street
Boston, Massachusetts 02108

USEPA New England Region 1
1 Congress Street, Suite 1100
Boston, Massachusetts 02114

ENSR International
2 Technology Park Drive
Westford, MA 01886

NOTICE OF AVAILABILITY

Limited copies of this report are available at no cost by written request to:

Massachusetts Department of Environmental Protection (MADEP)
Division of Watershed Management
627 Main Street
Worcester, Massachusetts 01608

This report is also available from MADEP's home page on the World Wide Web.

A complete list of reports published since 1963 is updated annually and printed in July. This list, titled "Publications of the Massachusetts Division of Watershed Management (DWM) – Watershed Planning Program, 1963-(current year)", is also available by writing to the DWM in Worcester.

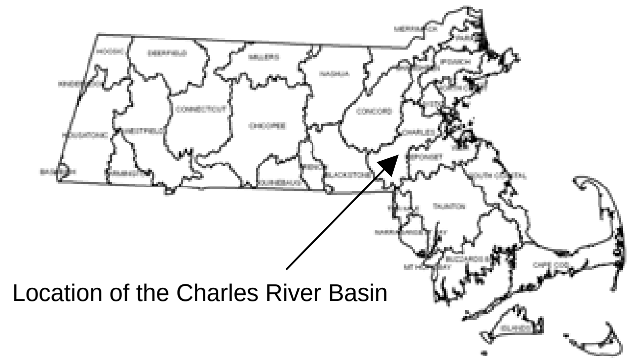
DISCLAIMER

References to trade names, commercial products, manufacturers, or distributors in this report constituted neither endorsement nor recommendations by the Division of Watershed Management for use.

Much of this document was prepared using text and general guidance from the previously approved Neponset River Basin and the Palmer River Basin Bacteria Total Maximum Daily Load documents.

Acknowledgement
This report was developed by ENSR through a partnership with Resource Triangle Institute (RTI) contracting with the United States Environmental Protection Agency (EPA) and the Massachusetts Department of Environmental Protection Agency under the National Watershed Protection Program.

Draft Total Maximum Daily Loads for Pathogens within the Charles River Watershed



Key Features: Pathogen TMDL for the Charles River Watershed

Location: EPA Region 1

Land Type: New England Upland

303(d) Listings: Pathogens

Beaver Brook (MA72-28); Bogastow Brook (MA72-16); Charles River (MA72-01; MA72-02; MA72-03; MA72-04; MA72-05; MA72-06; MA72-07; MA72-08); Cheese Cake Brook (MA72-29); Fuller Brook (MA72-18); Muddy River (MA72-11); Rock Meadow Brook (MA72-21); Rosemary Brook (MA72-21); Sawmill Brook (MA72-23); South Meadow Brook (MA72-24); Stop River (MA72-10); Unnamed Tributaries (MA72-30; MA72-32)

Data Sources:

- MADEP "Charles River Watershed 1997/1998 Water Quality Assessment Report"
- EPA Office of Environmental Measurement and Evaluation "Clean Charles 2005 Water Quality Report" 2001, 2002 and 2003 Core Monitoring Programs
- MWRA "Eutrophication of the lower Charles, Mystic and Neponset rivers, and of Boston Harbor: a statistical comparison"
- MWRA "Summary of CSO Receiving Water Quality Monitoring in Boston Harbor and Tributary Rivers, 1989 – 2001" Draft Report 2003
- CRWA Water Quality Sampling Data1995-2004
- USGS "Streamflow, Water Quality, and Contaminant Loads in the Lower Charles River Watershed, Massachusetts, 1999-2000"
- Metcalf & Eddy "Evaluation of Stormwater Management Benefits to the Lower Charles River"

Data Mechanism: Massachusetts Surface Water Quality Standards for Fecal Coliform; Massachusetts Department of Public Health Bathing Beaches

Monitoring Plan: Massachusetts Watershed Five-Year Cycle

Control Measures: Watershed Management; Storm Water Management (e.g., illicit discharge removals, public education/behavior modification); CSO & SSO Abatement; Agricultural and other BMPs; By-laws; Ordinances; Septic System Maintenance/Upgrades

Executive Summary

Purpose and Intended Audience

This document provides a framework to address bacterial and other fecal-related pollution in surface waters of Massachusetts. Fecal contamination of our surface waters is most often a direct result of the improper management of human wastes, excrement from barnyard animals, pet feces and agricultural applications of manure. It can also result from large congregations of birds such as geese and gulls. Illicit discharges of boat waste are of particular concern in coastal areas. Inappropriate disposal of human and animal wastes can degrade aquatic ecosystems and negatively affect public health. Fecal contamination can also result in closures of shellfish beds, beaches, swimming holes and drinking water supplies. The closure of such important public resources can erode quality of life and diminish property values.

Who should read this document?

The following groups and individuals can benefit from the information in this report:

a) towns and municipalities, especially Phase I and Phase II storm water communities, that are required by law to address storm water and/or combined sewage overflows (CSOs) and other sources of contamination (e.g., broken sewerage pipes and illicit connections) that contribute to a waterbody's failure to meet Massachusetts Water Quality Standards for pathogens;

b) watershed groups that wish to pursue funding to identify and/or mitigate sources of pathogens in their watersheds;

c) public health officials and/or municipalities that are responsible for monitoring, enforcing or otherwise mitigating fecal contamination that results in beach closures or results in the failure of other surface waters to meet Massachusetts standards for pathogens;

d) citizens that wish to become more aware of pollution issues and may be interested in helping build local support for funding remediation measures.

TMDL Overview

The Massachusetts Department of Environmental Protection (MADEP) is responsible for monitoring the waters of the Commonwealth, identifying those waters that are impaired, and developing a plan to bring them back into compliance with the Massachusetts Water Quality Standards (WQS). The list of impaired waters, better known as the "303d list" identifies problem lakes, coastal waters and specific segments of rivers and streams and the reason for impairment.

Once a water body is identified as impaired, the MADEP is required by the Federal Clean Water Act (CWA) to develop a “pollution budget” designed to restore the health of the impaired body of water. The process of developing this budget, generally referred to as a Total Maximum Daily Load (TMDL), includes identifying the source(s) of the pollutant from direct discharges (point sources) and indirect discharges (non-point sources), determining the maximum amount of the pollutant that can be discharged to a specific water body to meet water quality standards, and assigning pollutant load allocations to the sources. A plan to implement the necessary pollutant reductions is essential to the ultimate achievement of meeting the water quality standards.

Pathogen TMDL: This report represents a TMDL for pathogen indicators (e.g. fecal coliform, *E. coli*, and enterococcus bacteria) in the Charles River Watershed. Certain bacteria, such as coliform, *E. coli*, and enterococcus bacteria, are indicators of contamination from sewage and/or the feces of warm-blooded wildlife (mammals and birds). Such contamination may pose a risk to human health. Therefore, in order to prevent further degradation in water quality and to ensure that waterbodies within the watershed meet state water quality standards, the TMDL establishes indicator bacteria limits and outlines corrective actions to achieve that goal.

Sources of indicator bacteria in the Charles River Watershed were found to be many and varied. Most of the bacteria sources are believed to be storm water related. Table ES-1 provides a general compilation of likely bacteria sources in the Charles River Watershed including failing septic systems, combined sewer overflows (CSO), sanitary sewer overflows (SSO), sewer pipes connected to storm drains, certain recreational activities, wildlife including birds along with domestic pets and animals and direct overland storm water runoff. Note that bacteria from wildlife would be considered a natural condition unless some form of human inducement, such as feeding, is causing congregation of wild birds or animals. A discussion of pathogen related control measures and best management practices are provided in the companion document: “*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*”.

This TMDL applies to the 20 pathogen impaired segments of the Charles River Watershed that are currently listed on the CWA § 303(d) list of impaired waters. MADEP recommends however, that the information contained in this TMDL guide management activities for all other waters throughout the watershed to help maintain and protect existing water quality. For these non-impaired waters, Massachusetts is proposing “pollution prevention TMDLs” consistent with CWA § 303(d)(3).

The analyses conducted for the pathogen impaired segments in this TMDL would apply to the non-impaired segments, since the sources and their characteristics are equivalent. The waste load and/or load allocation for each source and designated use would be the same as specified herein. Therefore, the pollution prevention TMDLs would have identical waste load and load allocations based on the sources present and the designated use of the water body segment (see Table ES-1 and Table 6-1).

This Charles River Watershed TMDL may, in appropriate circumstances, also apply to segments that are listed for pathogen impairment in subsequent Massachusetts CWA § 303(d) Integrated List of Waters. For such segments, this TMDL may apply if, after listing the waters for pathogen impairment and taking into account all relevant comments submitted on the CWA § 303(d) list, the Commonwealth determines with EPA approval of the CWA § 303(d) list that this TMDL should apply to future pathogen impaired segments.

Since accurate estimates of existing sources are generally unavailable, it is difficult to estimate the pollutant reductions for specific sources. For the illicit sources, the goal is complete elimination (100% reduction). However, overall wet weather indicator bacteria load reductions can be estimated using typical storm water bacteria concentrations. These data indicate that in general two to three orders of magnitude (i.e., greater than 90%) reductions in storm water fecal coliform loading will be necessary, especially in developed areas. This goal is expected to be accomplished through implementation of best management practices, such as those associated with the Phase II control program for storm water.

TMDL goals for each type of bacteria source are provided in Table ES-1. Municipalities are the primary responsible parties for eliminating many of these sources. TMDL implementation to achieve these goals should be an iterative process with selection and implementation of mitigation measures followed by monitoring to determine the extent of water quality improvement realized. Recommended TMDL implementation measures include identification and elimination of prohibited sources such as leaky or improperly connected sanitary sewer flows and best management practices to mitigate storm water runoff volume. Certain towns in the watershed are classified as Urban Areas by the United States Census Bureau and are subject to the Stormwater Phase II Final Rule that requires the development and implementation of an illicit discharge detection and elimination plan. Combined sewer overflows will be addressed through the on-going long-term control plans.

In most cases, authority to regulate non-point source pollution and thus successful implementation of this TMDL is limited to local government entities and will require cooperative support from local volunteers, watershed associations, and local officials in municipal government. Those activities can take the form of expanded education, obtaining and/or providing funding, and possibly local enforcement. In some cases, such as subsurface disposal of wastewater from homes, the Commonwealth provides the framework, but the administration occurs on the local level. Among federal and state funds to help implement this TMDL are, on a competitive basis, the Non-Point Source Control (CWA Section 319) Grants, Water Quality (CWA Section 604(b)) Grants, and the State Revolving (Loan) Fund Program (SRF). Most financial aid requires some local match as well. The programs mentioned are administered through the MADEP. Additional funding and resources available to assist local officials and community groups can be referenced within the Massachusetts Non-point Source Management Plan-Volume I Strategic Summary (2000) "Section VII Funding / Community Resources". This document is available on the MADEP's website at: www.state.ma.us/dep/brp/wm/wmpubs.htm, or by contacting the MADEP's Nonpoint Source Program at (508) 792-7470 to request a copy.

Table ES-1. Sources and Expectations for Limiting Bacterial Contamination in the Charles River Watershed

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL)[1]	Load Allocation Indicator Bacteria (CFU/100 mL)[1]
A & B	Illicit discharges to storm drains	0	N/A
A & B	Leaking sanitary sewer lines	0	N/A
A & B	Failing septic systems	N/A	0
A	NPDES – WWTP	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples, nor shall 10% of the samples exceed 100 organisms[2]	N/A
A	Storm water runoff Phase I and II	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples, nor shall 10% of the samples exceed 100 organisms[3]	N/A
A	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples, nor shall 10% of the samples exceed 100 organisms[3]
B	CSOs	Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[4]	N/A
B	NPDES – WWTP	Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[2]	N/A
B	Storm water runoff Phase I and II	Not to exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[3]	N/A
B	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[3]

Surface Water Classification	**Pathogen Source**	**Waste Load Allocation Indicator Bacteria (CFU/100 mL)[1]**	**Load Allocation Indicator Bacteria (CFU/100 mL)[1]**
Fresh Water Beaches[5]	All Sources	Enterococci not to exceed a geometric mean of 33 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 61 colonies OR *E. coli* not to exceed a geometric mean of 126 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 235 colonies	Enterococci not to exceed a geometric mean of 33 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 61 colonies OR *E. coli* not to exceed a geometric mean of 126 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 235 colonies

N/A means not applicable

[1] Waste Load Allocation (WLA) and Load Allocation (LA) refer to fecal coliform densities unless specified in table.

[2] Or shall be consistent with the Waste Water Treatment Plant (WWTP) National Pollutant Discharge Elimination System (NPDES) permit.

[3]The expectation for WLAs and LAs for storm water discharges is that they will be achieved through the implementation of BMPs and other controls.

[4] Or shall be consistent with an approved Long Term Control Plan (LTCP) for Combined Sewer Overflow (CSO) abatement. If the level of control specified in the LTCP is less than what is necessary to attain Class B water quality standards, then the above criteria apply unless MADEP has proposed and EPA has approved water quality standards revisions for the receiving water.

[5] Massachusetts Department of Public Health regulations (105 CMR Section 445)

Note: this table represents waste load and load reductions based on water quality standards current as of the publication date of these TMDLs, any future changes made to the Massachusetts water quality standards will become the governing water quality standards for these TMDLs.

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1.0 Introduction

Section 303(d) of the Federal Clean Water Act (CWA) and Environmental Protection Agencies (EPA's) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to place waterbodies that do not meet established water quality standards on a list of impaired waterbodies (commonly referred to as the “303d List”) and to develop Total Maximum Daily Loads (TMDLs) for listed waters and the pollutant(s) contributing to the impairment. In Massachusetts, impaired waterbodies are included in Category 5 of the “*Massachusetts Year 2002 Integrated List of Water: Part 2- Final Listing of Individual Categories of Waters*” (*2002 List*; MADEP 2003). Figure 1-1 provides a map of the Charles River Watershed with pathogen impaired segments indicated. Please note that not all segments have been assessed by the Massachusetts Department of Environmental Protection (MADEP) for pathogen impairment. As shown in Figure 1-1, much of the Charles River waterbodies are listed as a Category 5 “impaired or threatened for one or more uses and requiring a TMDL” due to excessive indicator bacteria concentrations.

TMDLs are to be developed for water bodies that are not meeting designated uses under technology-based controls only. TMDLs determine the amount of a pollutant that a waterbody can safely assimilate without violating water quality standards. The TMDL process establishes the maximum allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollutant sources and instream conditions. The TMDL process is designed to assist states and watershed stakeholders in the implementation of water quality-based controls specifically targeted to identified sources of pollution in order to restore and maintain the quality of their water resources (USEPA 1999). TMDLs allow watershed stewards to establish measurable water quality goals based on the difference between site-specific instream conditions and state water quality standards.

A major goal of this TMDL is to achieve meaningful environmental results with regard to the designated uses of the Charles River waterbodies. These include water supply, fishing, boating, and swimming. This TMDL establishes the necessary pollutant load to achieve designated uses and water quality standard and the companion document entitled; “*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*” provides guidance for the implementation of this TMDL.

Historically, water and sediment quality studies have focused on the control of point sources of pollutants (i.e., discharges from pipes and other structural conveyances) that discharge directly into well-defined hydrologic resources, such as lakes, ponds, or river segments. While this localized approach may be appropriate under certain situations, it typically fails to characterize the more subtle and chronic sources of pollutants that are widely scattered throughout a broad geographic region such as a watershed (e.g., roadway runoff, failing septic systems in high groundwater, areas of concentrated wildfowl use, fertilizers, pesticides, pet waste, and certain agricultural sources). These so called nonpoint sources of pollution often contribute significantly to the decline of water quality through their cumulative impacts. A watershed-level approach that uses the surface drainage area as the basic study unit enables managers to gain a more complete understanding of the potential pollutant sources impacting a waterbody and increases the precision of identifying local

Figure 1-1. Charles River Watershed and Pathogen Impaired Segments

problem areas or “hot spots” which may detrimentally affect water and sediment quality. It is within this watershed-level framework that the MADEP commissioned the development of watershed based TMDLs.

1.1. Pathogens and Indicator Bacteria

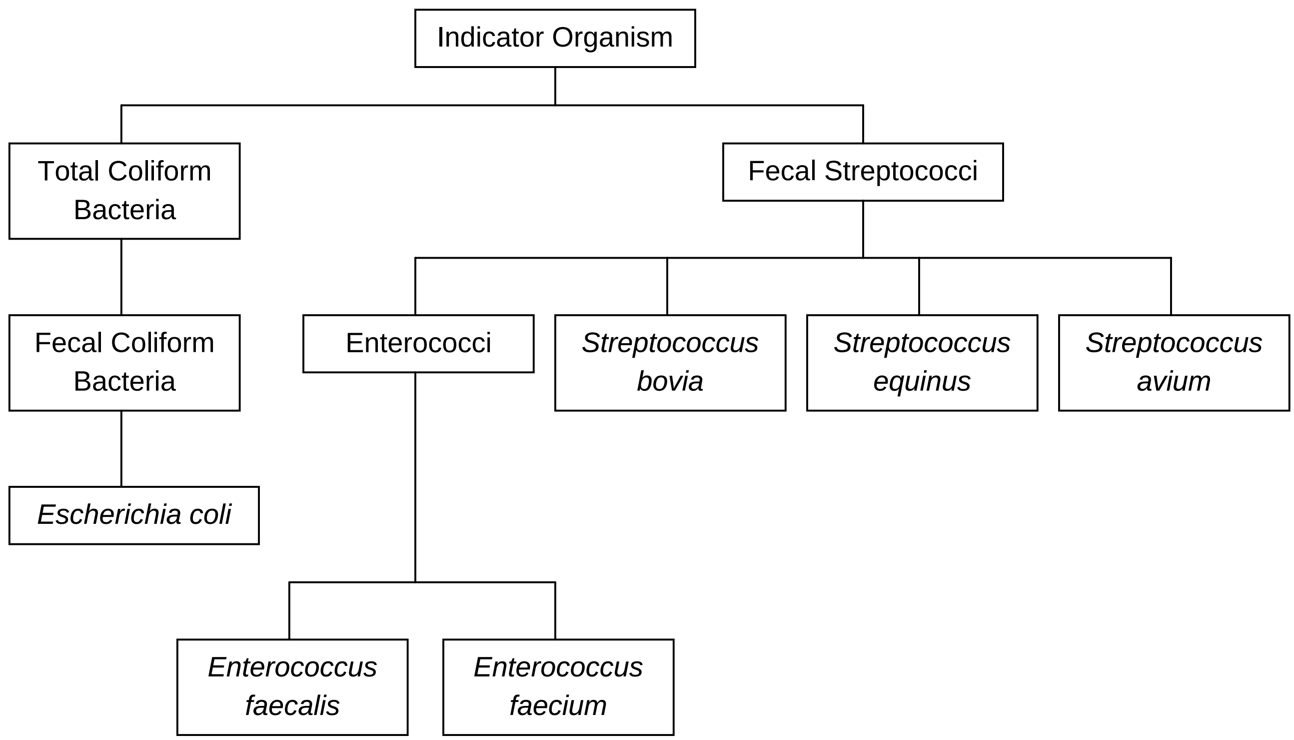
The Charles River pathogen TMDL is designed to support reduction of waterborne disease-causing organisms, known as pathogens, to reduce public health risk. Waterborne pathogens enter surface waters from a variety of sources including sewage and the feces of warm-blooded wildlife. These pathogens can pose a risk to human health due to gastrointestinal illness through exposure via ingestion and contact with recreational waters, ingestion of drinking water, and consumption of filter-feeding shellfish.

Waterborne pathogens include a broad range of bacteria and viruses that are difficult to identify and isolate. Thus, specific nonpathogenic bacteria have been identified that are typically associated with harmful pathogens in fecal contamination. These associated nonpathogenic bacteria are used as indicator bacteria as they are easier to identify and measure in the environment. High densities of indicator bacteria increase the likelihood of the presence of pathogenic organisms.

Selection of indicator bacteria is difficult as new technologies challenge current methods of detection and the strength of correlation of indicator bacteria and human illness. Currently, coliform and fecal streptococci bacteria are commonly used as indicators of potential pathogens (i.e., indicator bacteria). Coliform bacteria include total coliforms, fecal coliform and *Escherichia coli* (*E. coli*). Fecal coliform (a subset of total coliform) and *E. coli* (a subset of fecal coliform) bacteria are present in the intestinal tracts of warm blooded animals. Presence of coliform bacteria in water indicates fecal contamination and the possible presence of pathogens. Fecal streptococci bacteria are also used as indicator bacteria, specifically enterococci a subgroup of fecal streptococci. These bacteria also live in the intestinal tract of animals, but their presence is a better predictor of human gastrointestinal illness than fecal coliform since the die-off rate of enterococci is much lower (i.e., enterococci bacteria remain in the environment longer) (USEPA 2001a). The relationship of indicator organisms is provided in Figure 1-2. The EPA, in the “*Ambient Water Quality Criteria for Bacteria – 1986*” document, recommends the use of *E. coli* or enterococci as potential pathogen indicators in fresh water and enterococci in marine waters (USEPA 1986).

Massachusetts uses fecal coliform and enterococci as indicator organisms of potential harmful pathogens. The WQS that apply to fresh water are currently based on fecal coliform concentration but will be replaced with *E. coli.* Fecal coliform are also used by the Massachusetts Division of Marine Fisheries (DMF) in their classification of shellfish growing areas. Fecal coliform as the indicator organism for shellfish growing area status is not expected to change at this time. Enterococci are used as the indicator organism for marine beaches, as required by the Beaches Environmental Assessment and Coastal Act of 2000 (BEACH Act), an amendment to the CWA.

Figure 1-2. Relationships among Indicator Organisms (USEPA 2001a).



The Charles River Watershed pathogen TMDLs have been developed using fecal coliform as an indicator bacterium for fresh waters. Any changes in the Massachusetts pathogen water quality standard will apply to this TMDL at the time of the standard change. Massachusetts believes that the magnitude of indicator bacteria loading reductions outlined in this TMDL will be both necessary and sufficient to attain present WQS and any future modifications to the WQS for pathogens.

1.2. Comprehensive Watershed-based Approach to TMDL Development

Consistent with Section 303(d) of the CWA, the MADEP has chosen to complete pathogen TMDLs for all waterbodies in the Charles River Watershed at this time, regardless of current impairment status (i.e., for all waterbody categories in the *2002 List*). MADEP believes a comprehensive management approach carried out by all watershed communities is needed to address the ubiquitous nature of pathogen sources present in the Charles River Watershed. Watershed-wide implementation is needed to meet WQS and restore designated uses in impaired segments while providing protection of desirable water quality in waters that are not currently impaired or not assessed.

As discussed below, this TMDL applies to the 20 pathogen impaired segments of the Charles River Watershed that are currently listed on the CWA § 303(d) list of impaired waters and determined to be pathogen impaired in the "*Charles River Watershed 1997/1998 Water Quality Assessment Report"* (WQA; MADEP 2000a) (see Figure 1-1, Table 4-3). MADEP recommends however, that the information contained in this TMDL guide management activities for all other waters throughout the watershed to help maintain and protect existing water quality. For these non-impaired waters, Massachusetts is proposing “pollution prevention TMDLs” consistent with CWA § 303(d)(3).

The analyses conducted for the pathogen impaired segments in this TMDL would apply to the non-impaired segments, since the sources and their characteristics are equivalent. The waste load and/or load allocation for each source and designated use would be the same as specified herein. Therefore, the pollution prevention TMDLs would have identical waste load and load allocations based on the sources present and the designated use of the water body segment (see Table ES-1 and Table 6-1).

This Charles River Watershed TMDL may, in appropriate circumstances, also apply to segments that are listed for pathogen impairment in subsequent Massachusetts CWA § 303(d) Integrated List of Waters. For such segments, this TMDL may apply if, after listing the waters for pathogen impairment and taking into account all relevant comments submitted on the CWA § 303(d) list, the Commonwealth determines with EPA approval of the CWA § 303(d) list that this TMDL should apply to future pathogen impaired segments.

There are 83 waterbody segments assessed by the MADEP in the Charles River Watershed (MassGIS 2005). These segments consist of 31 river segments, 20 of which are pathogen impaired and appear as such on the official impaired waters list (303(d) List) (Figure 1-1). None of the 52 lake segments are pathogen impaired. Pathogen impairment has been documented by the MADEP in previous reports, including the MADEP WQA, resulting in the impairment determination. In this TMDL document, an overview of pathogen impairment is provided to illustrate the nature and extent of the pathogen impairment problem. Additional data, not collected by the MADEP or used to determine impairment status, may also be provided in this TMDL to illustrate the pathogen problem. Since pathogen impairment has been previously established only a summary is provided herein.

The watershed based approach applied to complete the Charles River Watershed pathogen TMDL is straightforward. The approach is focused on identification of sources, source reduction, and implementation of appropriate management plans. Once identified, sources are required to meet applicable WQS for indicator bacteria or be eliminated. This approach does not include water quality analysis or other approaches designed to link ambient concentrations with source loadings. For pathogens and indicator bacteria, water quality analyses are generally resource intensive and provide results with large degrees of uncertainty. Rather, this approach focuses on sources and required load reductions, proceeding efficiently toward water quality restoration activities.

The implementation strategy for reducing indicator bacteria is an iterative process where data are gathered on an ongoing basis, sources are identified and eliminated if possible, and control measures including Best Management Practices (BMPs) are implemented, assessed and modified as needed. Measures to abate probable sources of waterborne pathogens include everything from public education, to improved storm water management, to reducing the influence from inadequate and/or failing sanitary sewer infrastructure.

1.3. TMDL Report Format

This document contains the following sections:

- Watershed Description (Section 2) – provides watershed specific information
- Water Quality Standards (Section 3) – provides a summary of current Massachusetts WQS as they relate to indicator bacteria
- Problem Assessment (Section 4) – provides an overview of indicator bacteria measurements collected in the Charles River Watershed
- Identification of Sources (Section 5) – identifies and discusses potential sources of waterborne pathogens within the Charles River Watershed.
- TMDL Development (Section 6) – specifies required TMDL development components including:
    - Definitions and Equation
    - Loading Capacity
    - Load and Waste Load Allocations
    - Margin of Safety
    - Seasonal Variability
- Implementation Plan (Section 7) – describes specific implementation activities designed to remove pathogen impairment. This section and the companion "*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*" document should be used together to support implementing management actions.
- Monitoring Plan (Section 8) – describes recommended monitoring activities
- Reasonable Assurances (Section 9) – describes reasonable assurances the TMDL will be implemented
- Public Participation (Section 10) – describes the public participation process, and
- References (Section 11)

2.0 Watershed Description

The Charles River is approximately 80 miles in length and drains 307 square miles (MADEP 2000a). The watershed includes 35 cities and towns within eastern Massachusetts. The Charles River begins in the Town of Hopkinton at approximately 500 feet above mean sea level and drains to the Boston Harbor. Land use within the watershed is primarily forest and residential areas (Table 2-1). Most of the forested areas lie within the upper portion of the watershed whereas dense residential areas are located in the lower portion (Figure 2-1). A discussion of land use characteristics and associated indicator bacteria levels are provided in Section 4.0 of this document.

The Charles River hydrology is impacted by 20 dams along the length of the river and substantial natural storage in the upper and middle watershed. It has been estimated that it takes three to four days for peak flows in the upper portion to reach the Lower Charles (MADEP 2000a). These areas also allow for the release of stored water during periods of low flow.

The Charles River and tributaries are commonly used for primary and secondary contact recreation (swimming and boating), fishing, wildlife viewing, habitat for aquatic life, and drinking water supply.

Table 2-1. Charles River Watershed Land Use as of 1999.

Land Use Category	% of Total Watershed Area
Pasture	0.8
Urban Open	4.1
Open Land	2.2
Cropland	2.4
Woody Perennial	0.3
Forest	36.8
Wetland	2.9
Water Based Recreation	<0.1
Water	2.2
General Undeveloped Land	**51.8**
Spectator Recreation	0.1
Participation Recreation	2.6
> 1/2 acre lots Residential	12.9
1/4 - 1/2 acre lots Residential	11.3
< 1/4 acre lots Residential	9.7
Multi-family Residential	3.7
Mining	0.3
Commercial	2.9
Industrial	2.3
Transportation	2.2
Waste Disposal	0.2
General Developed Land	**48.2**

Figure 2-1. Charles River Watershed Land Use as of 1999.

3.0 Water Quality Standards

The Surface Water Quality Standards (WQS) for the Commonwealth of Massachusetts establish chemical, physical, and biological standards for the restoration and maintenance of the most sensitive uses (MADEP 2000b). The WQS limit the discharge of pollutants to surface waters for the protection of existing uses and attainment of designated uses in downstream and adjacent segments.

Fecal coliform, enterococci, and *E. coli* bacteria are found in the intestinal tract of warm-blooded animals, soil, water, and certain food and wood processing wastes. “Although they are generally not harmful themselves, they indicate the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoans that also live in human and animal digestive systems” (USEPA 2004a). These bacteria are often used as indicator bacteria since it is expensive and sometimes difficult to test for the presence of individual pathogenic organisms.

Massachusetts is planning to revise its freshwater WQS by replacing fecal coliform with *E. coli* and enterococci as the regulated indicator bacteria, as recommended by the EPA in the “*Ambient Water Quality Criteria for Bacteria – 1986*” document (USEPA 1986). The state has already done so for public beaches through regulations of the Massachusetts Department of Public Health as discussed below. Currently, Massachusetts uses fecal coliform as the indicator organism for all waters except for marine bathing beaches, where the Federal BEACH Act requires the use of enterococci. Massachusetts anticipates adopting *E. coli* and enterococci for all fresh waters and enterococci for all marine waters, including non bathing marine beaches. Fecal coliform will remain the indicator organism for shellfishing areas, however. The Charles River Watershed pathogen TMDL has been developed using fecal coliform as the pathogen indicator for fresh waters, but the goal of removing pathogen impairment of this TMDL will remain applicable when Massachusetts adopts new indicator bacteria criteria into its WQS. Massachusetts believes that the magnitude of indicator bacteria loading reductions outlined in this TMDL will be both necessary and sufficient to attain present WQS and any future modifications to the WQS for pathogens.

Pathogens can significantly impact humans through ingestion of, and contact with recreational waters, ingestion of drinking water, and consumption of filter-feeding shellfish. In addition to contact recreation, excessive pathogen numbers impact potable water supplies. The amount of treatment (i.e., disinfection) required to produce potable water increases with increased pathogen contamination. Such treatment may cause the generation of disinfection by-products that are also harmful to humans. Further detail on pathogen impacts can be accessed at the following EPA websites:

- Water Quality Criteria: Microbial (Pathogen)
  http://www.epa.gov/ost/humanhealth/microbial/microbial.html
- Human Health Advisories:
  - Fish and Wildlife Consumption Advisories
    http://www.epa.gov/ebtpages/humaadvisofishandwildlifeconsumption.html

- o Swimming Advisories
  http://www.epa.gov/ebtpages/humaadvisoswimmingadvisories.html

The Charles River Watershed contains waterbodies classified as Class A and Class B. The corresponding WQS for each class are as follows:

> Class A waterbodies - fecal coliform bacteria shall not exceed an arithmetic mean of 20 organisms per 100 mL in any representative set of samples, nor shall 10% of the samples exceed 100 organisms per 100 mL.
>
> Class B waterbodies - the geometric mean of a representative set of fecal coliform samples shall not exceed 200 organisms per 100 mL and no more than 10% of the samples shall exceed 400 organisms per 100 mL. The MADEP may apply these standards on a seasonal basis.

In addition to the WQS, the Commonwealth of Massachusetts Department of Public Health (MADPH) has established minimum standards for bathing beaches (105 CMR 445.000) under the State Sanitary Code, Chapter VII (www.mass.gov/dph/dcs/bb4_01.pdf). These standards will soon be adopted by the MADEP as state surface WQS for fresh water and these standards will subsequently apply to this TMDL. The MADPH bathing beach standards are generally the same as those which were recommended in the "*Ambient Water Quality Criteria for Bacteria – 1986"* document published by the EPA (USEPA 1986). In the above referenced document, the EPA recommended the use of enterococci as the indicator bacterium for marine recreational waters and enterococci or *E. coli* for fresh waters. As such, the following MADPH standards have been established for bathing beaches in Massachusetts:

> Marine Waters - (1) No single enterococci sample shall exceed 104 colonies per 100 mL and the geometric mean of the most recent five enterococci levels within the same bathing season shall not exceed 35 colonies per 100 mL.
>
> Freshwaters - (1) No single *E. coli* sample shall exceed 235 colonies per 100 mL and the geometric mean of the most recent five *E. coli* samples within the same bathing season shall not exceed 126 colonies per 100 mL; or (2) No single enterococci sample shall exceed 61 colonies per 100 mL and the geometric mean of the most recent five enterococci samples within the same bathing season shall not exceed 33 colonies per 100 mL.

The Federal BEACH Act of 2000 established a Federal standard for marine beaches. These standards are essentially the same as the MADPH marine beach standard (i.e., single sample not to exceed 104 cfu/100mL and geometric mean of a statistically sufficient number of samples not to exceed 35 cfu/100mL). The Federal BEACH Act and MADPH standards can be accessed on the worldwide web at http://www.epa.gov/waterscience/beaches/act.html and www.mass.gov/dph/dcs/bb4_01.pdf, respectively.

There are no marine bathing beaches in the Massachusetts portion of the Charles River Watershed. However, there are numerous freshwater beaches located within the watershed. A list of fresh (and marine) beaches by community with bacteria data can be found in the annual reports on the testing of public and semi-public beaches provided by the MADPH. These reports are available for download from the MADPH website located at http://www.mass.gov/dph/beha/tox/reports/beach/beaches.htm.

4.0 Problem Assessment

Pathogen impairment has been documented at numerous locations throughout the Charles River Watershed, as shown in Figure 1-1. Excessive concentrations of indicator bacteria (e.g., fecal coliform, enterococci, *E. coli* etc.) can indicate the presence of sewage contamination and possible presence of pathogenic organisms. The amount of indicator bacteria and potential pathogens entering waterbodies is dependent on several factors including watershed characteristics and meteorological conditions. Indicator bacteria levels generally increase with increasing development activities, including increased impervious cover, illicit sewer connections, and failed septic systems.

Indicator bacteria levels also tend to increase with wet weather conditions as storm sewer systems overflow and/or storm water runoff carries fecal matter that has accumulated to the river via overland flow and storm water conduits. In some cases, dry weather bacteria concentrations can be higher when there is a constant source that becomes diluted during periods of precipitation, such as with illicit connections. The magnitude of these relationships is variable, however, and can be substantially different temporally and spatially throughout the United States or within each watershed.

Tables 4-1 and 4-2 provide ranges of fecal coliform concentrations in storm water associated with various land use types. Pristine areas are observed to have low indicator bacteria levels and residential areas are observed to have elevated indicator bacteria levels. Development activity generally leads to decreased water quality (e.g., pathogen impairment) in a watershed. Development-related watershed modification includes increased impervious surface area which can (USEPA 1997):

- Increase flow volume,
- Increase peak flow,
- Increase peak flow duration,
- Increase stream temperature,
- Decrease base flow, and
- Change sediment loading rates.

Many of the impacts associated with increased impervious surface area also result in changes in pathogen loading (e.g., increased sediment loading can result in increased pathogen loading). In addition to increased impervious surface impacts, increased human and pet densities in developed areas increase potential fecal contamination. Furthermore, storm water drainage systems and associated storm water culverts and outfall pipes often result in the channelization of streams which leads to less attenuation of pathogen pollution.

Table 4-1. Wachusett Reservoir Storm Water Sampling (as reported in MADEP 2002) original data provided in MDC Wachusett Storm Water Study (June 1997).

Land Use Category	Fecal Coliform Bacteria[1] Organisms / 100 mL
Agriculture, Storm 1	110 – 21,200
Agriculture, Storm 2	200 – 56,400
"Pristine" (not developed, forest), Storm 1	0 – 51
"Pristine" (not developed, forest), Storm 2	8 – 766
High Density Residential (not sewered, on septic systems), Storm 1	30 – 29,600
High Density Residential (not sewered, on septic systems), Storm 2	430 – 122,000

[1] Grab samples collected for four storms between September 15, 1999 and June 7, 2000

Table 4-2. Lower Charles River Basin Storm Water Event Mean Bacteria Concentrations (data summarized from USGS 2002a)[1].

Land Use Category	Fecal Coliform (CFU/100 mL)	Enterococcus Bacteria (CFU/100 mL)	Number of Events
Single Family Residential	2,800 – 94,000	5,500 – 87,000	8
Multifamily Residential	2,200 – 31,000	3,200 – 49,000	8
Commercial	680 – 28,000	2,100 – 35,000	8

[1] An Event Mean Concentration (EMC) is the concentration of a flow proportioned sample throughout a storm event. These samples are commonly collected using an automated sampler which can proportion sample aliquots based on flow.

Pathogen impaired river segments represent 80.4% of the total river miles assessed (121.5 miles of impairment; 151.1 miles assessed) (MassGIS 2005). In total, 20 segments, each in need of a TMDL, contain indicator bacteria concentrations in excess of the Massachusetts WQS for Class A or B waterbodies (314 CMR 4.05)[1] and/or the MADPH standard for bathing beaches[2]. The basis for impairment listings is provided in the *2002 List* (MADEP 2003). Data presented in the WQA and other data collected by the MADEP were used to generate the *2002 List*. For more information regarding the basis for listing particular segments for pathogen impairment, please see the Assessment Methodology section of the MADEP WQA for this watershed.

A list of pathogen impaired segments requiring TMDLs is provided in Table 4-3. Segments are listed and discussed in hydrologic order (upstream to downstream) in the following sections. Additional details regarding each impaired segment including water withdrawals, discharges, use assessments and recommendations to meet use criteria are provided in the MADEP WQA.

An overview of the Charles River Watershed pathogen impairment is provided in this section to illustrate the nature and extent of the impairment. Since pathogen impairment has been previously established and documented on the *2002 List*, it is not necessary to provide detailed documentation of pathogen impairment herein.

This TMDL was based on the current WQS using fecal coliform as an indicator organism for fresh waters. The MADEP is in the process of developing new WQS incorporating *E. coli* and enterococci as indicator organisms for all waters other than shellfishing and potable water intake areas. Not all data presented herein were used to determine impairment listing due to a variety of reasons (including data quality assurance and quality control). The MADEP used only a subset of the available data to generate the *2002 List*. Data from the MADEP, EPA Region 1, Massachusetts Water Resources Authority (MWRA), the Charles River Watershed Association (CRWA), and United States Geological Survey (USGS) were reviewed and are summarized by segment below for illustrative purposes.

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[1] Class A: Fecal coliform bacteria shall not exceed an arithmetic mean of 20 organisms per 100 mL in any representative set of samples, nor shall 10% of the samples exceed 100 organisms per 100 mL.
Class B: Fecal coliform bacteria shall not exceed a geometric mean of 200 organisms per 100 mL in any representative set of samples, nor shall 10% of the samples exceed 400 organisms per 100 mL. The MADEP may apply these standards on a seasonal basis.

[2] Freshwater bathing beaches: No single *E. coli* sample shall exceed 235 colonies per 100 mL and the geometric mean of the most recent five *E. coli* samples within the same bathing season shall not exceed 126 colonies per 100 mL; or No single enterococci sample shall exceed 61 colonies per 100 mL and the geometric mean of the most recent five (5) enterococci samples within the same bathing season shall not exceed 33 colonies per 100 mL.

Table 4-3. Charles River Pathogen Impaired Segments Requiring TMDLs (adapted from MADEP 2003 and MassGIS 2005).

Segment ID	Segment Name	Length (miles)	Segment Description
MA72-01	Charles River	2.4	Source, outlet Echo Lake, Hopkinton to Dilla Street, Milford.
MA72-02	Charles River	3.1	Dilla Street, Milford to Milford WWTP, Hopedale.
MA72-03	Charles River	3.1	Milford WWTP, Hopedale to outlet Box Pond, Bellingham.
MA72-04	Charles River	11.4	Outlet Box Pond, Bellingham to outlet Populatic Pond, Norfolk/Medway.
MA72-05	Charles River	17.9	Outlet Populatic Pond, Norfolk/Medway to South Natick Dam, Natick.
MA72-10	Stop River	4.1	Norfolk-Walpole MCI, Norfolk to confluence with Charles River, Medfield.
MA72-16	Bogastow Brook	9.3	Outlet Factory Pond, Holliston to inlet South End Pond, Millis.
MA72-06	Charles River	8.0	South Natick Dam, Natick to Chestnut Street, Needham.
MA72-18	Fuller Brook	4.4	Headwaters south of Route 135, Needham to confluence with Waban Brook, Wellesley.
MA72-07	Charles River	23.2	Chestnut Street, Needham to Watertown Dam, Watertown.
MA72-21	Rock Meadow Brook	3.8	Headwaters in Fisher Meadow, Westwood through Stevens Pond and Lee Pond, Westwood to confluence Charles River, Dedham.
MA72-23	Sawmill Brook	2.7	Headwaters, Newton to confluence with Charles River, Boston.
MA72-24	South Meadow Brook	2.1	Isolated, interrupted, urban brook with 'headwaters' south of Route 9, Newton to confluence of Charles River, Newton.
MA72-25	Rosemary Brook	3.2	Headwaters, outlet Rosemary Lake, Needham to confluence with Charles River, Wellesley.
MA72-28	Beaver Brook	8.0	Headwaters, south of Route 2, Lexington through culverting to Charles River, Waltham.
MA72-29	Cheese Cake Brook	1.4	Headwaters, West Newton to confluence with Charles River, Newton.
MA72-08	Charles River	8.6	(Charles Basin) Watertown Dam, Watertown to Science Museum, Boston.
MA72-30	Unnamed Tributary	0.1	Unnamed tributary locally known as Laundry Brook. Emerges north of California Street, Watertown and flows north to confluence with Charles River, Watertown.
MA72-32	Unnamed tributary	0.5	Locally known as Sawins Brook. Headwaters east of Elm Street to confluence with Charles River, Watertown (sections culverted).
MA72-11	Muddy River	4.2	Outlet of unnamed pond, Olmstead Park, Boston to confluence with Charles River, Boston.

Data summarized in the following subsections may be found at:

- **CRWA** - downloaded from the CRWA website (http://www.crwa.org) under monthly water quality data or daily for the flagging program.
- **MADEP WQA** – Charles River Watershed 1997/1998 Water Quality Assessment Report available for download at http://www.mass.gov/dep/brp/wm/wqassess.htm.
- **EPA Core Monitoring Program** – Clean Charles 2005 Water Quality Reports available for download at http://www.epa.gov/boston/charles/2005.html
- **USGS** - Streamflow, Water Quality, and Contaminant Loads in the Lower Charles River Watershed, Massachusetts, 1999-2000 available for download at http://water.usgs.gov/pubs/wri/wri024137/
- **MWRA** - Summary of CSO Receiving Water Quality Monitoring in Boston Harbor and Tributary Rivers, 1989 – 2001 DRAFT report. Available by contacting the MWRA (http://www.mwra.state.ma.us/)

Data are broken down into two weather conditions: wet and dry. When data were not categorized as such in individual reports, data collected on days when there was measurable precipitation were considered wet weather conditions and data collected on days when no or "trace" amounts of precipitation were reported were considered dry weather conditions. It should be noted that some reporting entities require a minimum amount of precipitation (i.e., 0.1 or 0.2 inches) before it is considered wet weather. Therefore, data between reporting entities may not be directly comparable, but overall conclusions for each segment are consistent.

The summary tables for each segment contain the data source and the calendar years data were collected (i.e., CRWA 1995-2003). The "Site #" column displays the sampling location identifier issued by sampling organization. The "Description" column provides a short narrative description of the sampling location. The "Town" column provides the town name in which samples were collected. The next three columns provide statistics relating to sampling conducted during dry weather. These columns include "Min" where the minimum value reported is displayed, "Max" where the maximum value reported is displayed and "n" where the number of samples analyzed at that site over the time frame indicated. The same statistics are provided for data collected under wet weather conditions in the next three columns. It should be noted that many of these data sources also provide sampling results for other pathogen indicators (e.g., *E. coli* and enterococci), but are not summarized within the tables in the following subsection. However, figures illustrating *E. coli* and enterococci sampling results for the Lower Charles River, provided by the EPA and MWRA, are included as Figures 4-3 and 4-6 presented in the Charles River segment MA72-08 discussion in this report.

The MADPH publishes annual reports on the testing of public and semi-public beaches for both marine and fresh waters. These documents provide water quality data for each bathing beach by community and note if there were exceedances of water quality criteria. There is also a list of communities that did not report testing results. These reports can be downloaded from http://www.mass.gov/dph/beha/tox/reports/beach/beaches.htm. Marine and freshwater beach status is highly variable and is therefore not provided in each segment description. Please see the MADPH annual beach report for specific details regarding swimming beaches.

The purpose of this section of the report is to briefly describe the impaired waterbody segments in the Charles River Watershed. For more information on any of these segments, see the "*Charles River Watershed 1997/1998 Water Quality Assessment Report*" on the MADEP website: http://www.mass.gov/dep/brp/wm/wqassess.htm

Charles River Segment MA72-01

This segment is a 2.4 mile long Class A warm water fishery extending from Hopkinton to Milford. Portions of this segment and its drainage area serve as a public surface water supply in Hopkinton and public surface and groundwater water supply in Milford. See MADEP WQA for more information regarding this segment, available for download at http://www.mass.gov/dep/brp/wm/wqassess.htm.

CRWA October 1995 – December 2003 fecal coliform data for this segment are summarized in Table 4-4.

Table 4-4. MA72-01 Charles River Fecal Coliform Data Summary.

			Dry Weather (CFU/100 mL)			Wet Weather (CFU/100 mL)		
Site #	**Description**	**Town**	**Min**	**Max**	**n**	**Min**	**Max**	**n**
CRWA 1995-2003								
35CS	Central Street Bridge	Milford	<10	8,700	28	120	12,300	22
35CD	Discharge Pipe @ Central St.	Milford	290	49,000	28	490	37,000	21
35C2	2nd Discharge Pipe @ Central St.	Milford	<10	82,000	16	10	53,000	19

Charles River Segment MA72-02

This segment is a 3.1 mile long Class B warm water fishery extending from Milford to Hopedale. A public surface water supply, Lousia Lake, discharges to this segment. There are three groundwater withdrawals in this area for the Town of Milford. Two National Pollutant Discharge Elimination System (NPDES) permits were listed in the MADEP WQA: a Mobile station discharging from a groundwater remediation system to a storm sewer and a storm water runoff discharge from a parking area by A.J. Knott Tool & Mfg. See MADEP WQA for more information regarding this segment, available for download at http://www.mass.gov/dep/brp/wm/wqassess.htm.

Water quality sampling in this segment has been limited. However, the MADEP WQA stated that the CRWA documented sewage discharges into the Charles River at Central Street and in Godfrey Brook in the Integrated Monitoring, Modeling and Management (IM3) Project: Phase II Final Report (CRWA 1998), but raw data was not provided in the MADEP WQA. ENSR (1998) reported fecal coliform concentrations ranging from 233 to 42,000 cfu/100 mL during a survey performed in 1997.

Charles River Segment MA72-03

This segment is a 3.1 mile long Class B warm water fishery that extends from Hopedale to Bellingham. The Milford Waste Water Treatment Plant (WWTP) discharges to this segment. Water from the treatment plant is also utilized by Milford Power Limited Partnership (MPLP) for cooling during electricity generation. See MADEP WQA for more information regarding this segment, available for download at http://www.mass.gov/dep/brp/wm/wqassess.htm.

CRWA October 1995 – December 2003 fecal coliform data for this segment are summarized in Table 4-5.

Table 4-5. MA72-03 Charles River Fecal Coliform Data Summary.

			Dry Weather (CFU/100 mL)			Wet Weather (CFU/100 mL)		
Site #	**Description**	**Town**	**Min**	**Max**	**n**	**Min**	**Max**	**n**
CRWA 1995-2003								
59CS	Mellen St. Bridge	Bellingham	60	3,200	25	40	2,400	20

Charles River Segment MA72-04

This segment is an 11.4 mile long Class B warm water fishery extending from Bellingham to Norfolk/Medway. There are four public groundwater withdrawals in this area; three are located in Medway and one in Franklin. At the time of the MADEP WQA there were two additional groundwater withdrawals proposed. See MADEP WQA for more information regarding this segment, available for download at http://www.mass.gov/dep/brp/wm/wqassess.htm.

CRWA (October 1995 – December 2003) and MADEP WQA (July 1997 – April 1998) fecal coliform data for this segment are summarized in Table 4-6.

Table 4-6. MA72-04 Charles River Fecal Coliform Data Summary.

			Dry Weather (CFU/100 mL)			Wet Weather (CFU/100 mL)		
Site #	**Description**	**Town**	**Min**	**Max**	**n**	**Min**	**Max**	**n**
CRWA 1995-2003								
90CS	Rt. 126, N. Main St.	Bellingham	<10	3,400	28	8	1,090	19
13CS	Maple St. Bridge	Bellingham	<10	1,100	29	10	1,200	23
165S	Shaw St. Bridge	Franklin	10	2,400	15	20	3,500	19
199S	Populatic Pond Boat Launch	Norfolk	<10	5,600	18	40	500	16
MADEP WQA 1997-1998								
CR03	Walker Street	Medway	<20	500	6	80	120	2

Charles River Segment MA72-05

This segment is a 17.9 mile long Class B warm water fishery extending from Norfolk/Medway to Natick. There are three public groundwater withdrawals in this area, all located in the Town of Millis. There are two NPDES wastewater dischargers in this segment: the Charles River Water Pollution Control District (CRWPCD) discharges treated wastewater from the towns of Medway, Franklin, Bellingham, Millis, Dover, Norfolk, Sherborn, and Wrentham to the Charles River in Medway and the Medfield WWTP, discharging to the Charles River in Medfield. See MADEP WQA for more information regarding this segment, available for download at http://www.mass.gov/dep/brp/wm/wqassess.htm.

CRWA (October 1995 – December 2003) fecal coliform data for this segment are summarized in Table 4-7.

Table 4.7. MA72-05 Charles River Fecal Coliform Data Summary.

Site #	Description	Town	Dry Weather (CFU/100 mL)			Wet Weather (CFU/100 mL)		
			Min	Max	n	Min	Max	n
CRWA 1995-2003								
229S	Rt. 115, Baltimore St.	Norfolk/Millis	<10	2,800	27	10	2,000	23
267S	Dwight St. Bridge	Millis	<10	4,900	11	10	2,700	17
290S	Old Bridge St.	Medfield	<10	3,200	29	10	2,850	23
318S	Rt. 27 Bridge	Medfield	<10	2,100	28	10	1,600	20
343S	Farm Rd./Bridge St.	Sherborn/Dover	<10	3,000	15	10	720	20

Stop River Segment MA72-10

This segment is a 4.1 mile long Class B warm water fishery. This impaired segment is a tributary to the Charles River extending from Norfolk/Walpole to Medfield. There is one NPDES wastewater discharge, Norfolk MCI, in this segment. Although the upstream portion of the Stop River (segment MA72-09) is not a 2002 pathogen listed segment, there are two additional NPDES wastewater dischargers (Wrentham State School's WWTP located in Wrentham and the Southwood Community Hospital's treatment facility) that could potentially impact the MA72-10 segment of the Stop River. There are also seven groundwater withdrawals in this upstream segment. See MADEP WQA for more information regarding this segment, available for download at http://www.mass.gov/dep/brp/wm/wqassess.htm.

CRWA (October 1995 – December 2003) fecal coliform data for this segment are summarized in Table 4-8.

Table 4-8. MA72-10 Stop River Fecal Coliform Data Summary.

Site #	Description	Town	Dry Weather (CFU/100 mL)			Wet Weather (CFU/100 mL)		
			Min	Max	n	Min	Max	n
CRWA 1995-2003								
269T	Causeway St.	Medfield	<10	2,800	15	10	4,700	21

Bogastow Brook Segment MA72-16

This segment is a 9.3 mile long Class B high water quality waterbody. This impaired segment is the main tributary to South End Pond which discharges to the Charles River. This segment extends from Holliston to Millis. There are no NPDES wastewater discharges in this segment. However, there are suspected private septic system failures in the area (MADEP WQA). There are two public groundwater withdrawals located in Holliston and Millis and a community public water supply along the stream. See MADEP WQA for more information regarding this segment, available for download at http://www.mass.gov/dep/brp/wm/wqassess.htm.

MADEP WQA (July/August 1997) fecal coliform data for this segment are summarized in Table 4-9.

Table 4-9. MA72-16 Bogastow Brook Fecal Coliform Data Summary.

Site #	Description	Town	Dry Weather (CFU/100 mL)			Wet Weather (CFU/100 mL)		
			Min	Max	n	Min	Max	n
MADEP WQA 1997								
BB03	Lowland St.	Holliston	140	140	1	160	160	1
BB04	Fiske St.	Holliston				600	600	1
BB04A	Central St.	Holliston	180	180	1	300	300	1
BB05	Orchard St.	Holliston	160	160	1	460	460	1
BB06	Middlesex St.	Holliston	120	120	1	220	220	1
BB08	Bogastow Pond outlet	Millis	100	100	1	80	80	1

Charles River Segment MA72-06

This segment is an 8.0 mile long Class B warm water fishery extending from Natick to Needham. There are seven public groundwater withdrawals in this area. Two of these wells are located in Wellesley, three in Needham, and two in Dover. See MADEP WQA for more information regarding this segment, available for download at http://www.mass.gov/dep/brp/wm/wqassess.htm.

CRWA (October 1995 – December 2003), EPA Core Monitoring Program (June 2002 - September 2003), and MADEP WQA (July 1997 – April 1998) fecal coliform data for this segment are summarized in Table 4-10.

Table 4-10. MA7-06 Charles River Fecal Coliform Data Summary.

Site #	Description	Town	Dry Weather (CFU/100 mL)			Wet Weather (CFU/100 mL)		
			Min	Max	n	Min	Max	n
CRWA 1995-2003								
387S	Cheney Bridge	Wellesley	<10	2,100	26	10	500	22
400S	Charles River Road Bridge	Dover	<10	2,800	13	30	1,500	19
447S	Dover Gage	Dover	<10	3,100	18	10	310	17
EPA 2002-2003								
CRBL01	Downstream S. Natick Dam	Natick	20	60	5			
MADEP WQA 1997-1998								
CR02	Unnamed St northeast of Schaller St	Dover/Wellesley	20	200	5	60	160	2

Figures 4-1 and 4-2 provide a graphical representation of EPA fecal coliform data collected from 1998-2003, including station CRBL01 summarized in Table 4-10, as part of the Clean Charles 2005 Initiative. Figure 4-3 presents *E. coli* data collected in 2003 by the EPA. Figures 4-1 through 4-3 are presented within the Charles River Segment MA72-08 subsection of this report. A map showing sample locations for the EPA Clean Charles 2005 Water Quality Report is provided in Figure 4-4, also located in the Charles River Segment MA72-08 subsection of this report. Descriptions of sampling stations can be found in the Clean Charles 2005 Water Quality Report available for download at http://www.epa.gov/boston/charles/2005.html.

Fuller Brook Segment MA72-18

This segment is a 4.4 mile long Class B high water quality. This impaired segment is a tributary to Waban Brook (non-pathogen impaired segment MA72-17) which discharges to the Charles River. This impaired segment extends from Needham to Wellesley. There is one NPDES discharger along this segment, F. Diehl and Sons located in Wellesley. See MADEP WQA for more information regarding this segment, available for download at http://www.mass.gov/dep/brp/wm/wqassess.htm.

MADEP WQA (July 1997 – April 1998) fecal coliform data for this segment are summarized in Table 4-11.

Table 4-11. MA72-18 Fuller Brook Fecal Coliform Data Summary.

			Dry Weather (CFU/100 mL)			Wet Weather (CFU/100 mL)		
Site #	**Description**	**Town**	**Min**	**Max**	**n**	**Min**	**Max**	**n**
MADEP WQA 1997-1998								
FB01	Dover St.	Wellesley	40	4,000	6	300	1,500	3
FB02	Cameron St. (100 m upstream)	Wellesley				200	200	1
FB03	Cameron St. (102 m upstream)	Wellesley				1,600	1,600	1

Charles River Segment MA72-07

This segment is a 23.2 mile long Class B warm water fishery extending from Needham to Watertown. There are seven public groundwater withdrawals in this area. Five of these wells are located in Dedham and two are located in Weston. There are eight NPDES dischargers along this segment. See MADEP WQA for more information regarding this segment, available for download at http://www.mass.gov/dep/brp/wm/wqassess.htm.

CRWA (October 1995 – December 2003), EPA Core Monitoring Program (June 2002 - September 2003), USGS (June 1999 – September 2000) and MADEP WQA (July – November 1997) fecal coliform data for this segment are summarized in Table 4-12.

Table 4-12. MA72-07 Charles River Fecal Coliform Data Summary.

			Dry Weather (CFU/100 mL)			Wet Weather (CFU/100 mL)		
Site #	**Description**	**Town**	**Min**	**Max**	**n**	**Min**	**Max**	**n**
CRWA 1995-2003								
484S	Dedham Medical Center	Dedham	<10	1,690	28	20	2,500	20
521S	Ames St. Bridge	Dedham	<10	3,100	16	10	1,600	22
534S	Rt. 109 Bridge	Dedham	<10	3,600	29	30	1,600	23
567S	Nahanton Park	Newton	<10	2,200	17	10	900	22
591S	Rt. 9 Gaging Station	Newton	<10	520	12	10	1,800	17
609S	Washington St. Hunnewell Bridge	Wellesley	<10	1,800	26	10	1,600	23
621S	Leo J. Martin Golf Course/Park Rd.	Weston	<10	1,700	15	10	1,100	22
635S	2391 Commonwealth Ave.	Newton	<10	750	23	20	1,900	22
648S	Lakes Region	Waltham	<10	940	10	10	1,800	15
662S	Moody St. Bridge	Waltham	<10	1,200	28	20	580	23
675S	North St.	Waltham	20	2,200	14	70	1,100	21
012S	Watertown Dam Footbridge	Watertown	10	3,500	29	20	4,600	23
EPA 2002-2003								
CRBL02	Upstream Watertown Dam	Watertown	68	1,396	12	92	540	4
USGS 1999-2000 (mean, min & max reported for wet weather)								
01104615	Upstream Watertown Dam	Watertown	30	5,000	13	220	17,000	9
MADEP WQA 1997-1998								
CR01	Watertown Dam	Watertown	100	360	4			

Figures 4-1 and 4-2 provide a graphical representation of EPA fecal coliform data collected from 1998-2003, including station CRBL02 summarized in Table 4-12, as part of the Clean Charles 2005 Initiative. Figure 4-3 presents *E. coli* data collected in 2003. Figures 4-1 through 4-3 are presented within the Charles River Segment MA72-08 subsection of this report. A map showing sample locations for the EPA Clean Charles 2005 Water Quality Report is provided in Figure 4-4, also located in the Charles River Segment MA72-08 subsection of this report. Descriptions of sampling stations can be found in the Clean Charles 2005 Water Quality Report available for download at http://www.epa.gov/boston/charles/2005.html.

Graphical representation (box and whiskers plot) of one station (012) from the MWRA Draft CSO Report (Coughlin 2003) is provided in Figure 4-5 (fecal coliform data) and 4-6 (enterococci data), following the discussion relating to pathogen impaired Charles River Segment MA72-08. A sample location map for the MWRA Draft CSO Report can be found in Figure 4-7 in the Charles River Segment MA72-08 subsection of this report.

<u>Rock Meadow Brook Segment MA72-21</u>

This segment is a 3.8 mile long Class B waterbody. This impaired segment is a tributary to the Charles River extending from Westwood to Dedham. There are two inactive public groundwater withdrawals in this area. See MADEP WQA for more information regarding this segment, available for download at http://www.mass.gov/dep/brp/wm/wqassess.htm.

MADEP WQA (July 1997 – April 1998) fecal coliform data for this segment are summarized in Table 4-13.

Table 4-13. MA72-21 Rock Meadow Brook Fecal Coliform Data Summary.

			Dry Weather (CFU/100 mL)			Wet Weather (CFU/100 mL)		
Site #	**Description**	**Town**	**Min**	**Max**	**n**	**Min**	**Max**	**n**
MADEP WQA 1997-1998								
RM01	Summer St.	Westwood	<20	600	4	<20	60	2

Sawmill Brook Segment MA72-23

This segment is a 2.7 mile long Class B waterbody. This impaired segment is a tributary to the Charles River extending from Newton to Boston. There are no permitted withdrawals or NPDES discharges in this segment. See MADEP WQA for more information regarding this segment, available for download at http://www.mass.gov/dep/brp/wm/wqassess.htm.

MADEP WQA (July 1997 – April 1998) fecal coliform data for this segment are summarized in Table 4-14.

Table 4-14. MA72-23 Sawmill Brook Fecal Coliform Data Summary.

			Dry Weather (CFU/100 mL)			Wet Weather (CFU/100 mL)		
Site #	**Description**	**Town**	**Min**	**Max**	**n**	**Min**	**Max**	**n**
MADEP WQA 1997-1998								
SB01	Baker St.(10 m upstream)	Boston	520	7,000	4	780	3,000	2
SB02	Baker St.(100-200 m upstream)	Boston				200	200	1
SBE1	Baker St. storm pipe (100-200 m upstream)	Boston				4,000	4,000	1

South Meadow Brook Segment MA72-24

This segment is a 2.1 mile long Class B waterbody. This impaired segment is a tributary to the Charles River in Newton. There is one permitted NPDES discharger in this segment: The Atrium at Chestnut Hill. See MADEP WQA for more information regarding this segment, available for download at http://www.mass.gov/dep/brp/wm/wqassess.htm.

MADEP WQA (July 1997 – April 1998) fecal coliform data for this segment are summarized in Table 4-15.

Table 4-15. MA72-24 South Meadow Brook Fecal Coliform Data Summary.

			Dry Weather (CFU/100 mL)			Wet Weather (CFU/100 mL)		
Site #	**Description**	**Town**	**Min**	**Max**	**n**	**Min**	**Max**	**n**
MADEP WQA 1997-1998								
SM01	Neeham St.	Newton	200	3,600	6	1,800	2,000	2
SM02	Winchester St.	Newton				320	320	1
SME1	Winchester St. Storm pipe (3 m upstream)	Newton	200	200	1			

Rosemary Brook Segment MA72-25

This segment is a 3.2 mile long Class B waterbody. This impaired segment is a tributary to the Charles River extending from Needham to Wellesley. There are four groundwater wells in Wellesley proximal to this segment; however two of these wells are inactive. See MADEP WQA for more information regarding this segment, available for download at http://www.mass.gov/dep/brp/wm/wqassess.htm.

MADEP WQA (July 1997 – April 1998) fecal coliform data for this segment are summarized in Table 4-16.

Table 4-16. MA72-25 Rosemary Brook Fecal Coliform Data Summary.

			Dry Weather (CFU/100 mL)			Wet Weather (CFU/100 mL)		
Site #	**Description**	**Town**	**Min**	**Max**	**n**	**Min**	**Max**	**n**
MADEP WQA 1997-1998								
RB01	Barton Rd.	Wellesley	<20	200	6	40	180	2

Beaver Brook Segment MA72-28

This segment is a 3.2 mile long Class B waterbody. This impaired segment is a tributary to the Charles River extending from Lexington to Waltham. There are three NPDES discharges in this segment, W.R. Grace & Company and two discharges from Waverly Oaks Park Shell Oil Company. See MADEP WQA for more information regarding this segment, available for download at http://www.mass.gov/dep/brp/wm/wqassess.htm.

MADEP WQA (July 1997 – April 1998) fecal coliform data for this segment are summarized in Table 4-17.

Table 4-17. MA72-28 Beaver Brook Fecal Coliform Data Summary.

			Dry Weather (CFU/100 mL)			Wet Weather (CFU/100 mL)		
Site #	**Description**	**Town**	**Min**	**Max**	**n**	**Min**	**Max**	**n**
MADEP WQA 1997-1998								
BE00	River St.	Waltham	480	4,400	4	2,000	2,000	1
BE01	Route 60 (upstream)	Waltham	2,000	2,000	2	1,400	1,400	1
BEE1	Route 60 Storm pipe (downstream)	Waltham				480	480	1
BEE2	Route 60 Storm pipe (upstream)	Waltham				240	240	1

Cheese Cake Brook Segment MA72-29

This segment is a 1.4 mile long Class B waterbody. This impaired segment is a tributary to the Charles River extending from West Newton to Newton. There are two NPDES discharges in this segment, Radiant Fuels and Mobil Oil Corporation, both in Newton. See MADEP WQA for more information regarding this segment, available for download at http://www.mass.gov/dep/brp/wm/wqassess.htm.

MADEP WQA (July 1997 – April 1998) fecal coliform data for this segment are summarized in Table 4-18.

Table 4-18. MA72-29 Cheese Cake Brook Fecal Coliform Data Summary.

			Dry Weather (CFU/100 mL)			Wet Weather (CFU/100 mL)		
Site #	**Description**	**Town**	**Min**	**Max**	**n**	**Min**	**Max**	**n**
MADEP WQA 1997-1998								
CB01	10 m upstream of confluence	Newton	360	4,000	6	340	1,800	2
CB02	Crafts St.	Newton				1,200	1,200	1
CB05	Eddy St. (upstream)	Newton				1,200	1,200	1
CBE0	Crafts St. Storm pipe	Newton				<20	<20	1
CBE1	Watertown St. Storm pipe	Newton	50,000	50,000	1			
CBE2	Eddy St. Storm pipe (downstream)	Newton				260	260	1

Charles River Segment MA72-08

This segment is an 8.6 mile long Class B warm water fishery extending from the Watertown Dam in Watertown to Boston. According the MWRA "*Summary of CSO Receiving Water Quality Monitoring in Boston Harbor and Tributary Rivers, 1989 - 2001*" Draft Report, there are seven CSO outfalls that have been closed since March 2002, one CSO to be closed, one CSO with treatment (Cottage Farm Upgrade) and twelve untreated remaining (Coughlin 2003). There are three former or existing CSOs located along tributaries within this segment. Two of these CSO outfalls, located in an unnamed tributary (Segment MA72-32), are closed. The remaining tributary CSO is located in Muddy River (Segment MA72-11). A map showing the location and status of CSOs outfalls is provided in Appendix A from the MWRA (2004) along with a map from the USGS (2002b) showing the numerous storm drain outfalls and overland flow locations. There are also numerous NPDES dischargers in this area. See MADEP WQA for more information regarding this segment, available for download at http://www.mass.gov/dep/brp/wm/wqassess.htm.

CRWA (June – August 2004 and October 1995 – December 2003), EPA Core Monitoring Program (June 2002 - September 2003), USGS (June 1999 – September 2000) and MADEP WQA (December 1997 – April 1998) fecal coliform data for this segment are summarized in Table 4-19.

Table 4-19. MA72-08 Charles River Fecal Coliform Data Summary.

			Dry Weather (CFU/100 mL)			Wet Weather (CFU/100 mL)		
Site #	**Description**	**Town**	**Min**	**Max**	**n**	**Min**	**Max**	**n**
CRWA Lower Charles 2004 Flagging								
700S	N. Beacon St	Newton	140	660	9	250	3,300	4
	Larz Anderson Bridge	Boston	10	170	9	50	450	4
	Boston University Bridge	Boston	290	1,600	9	190	1,100	4
773S	Longfellow Bridge	Boston	<10	310	9	45	150	4
CRWA 1995-2003								
700S	N. Beacon St.	Newton	40	4,700	15	90	6,000	21
715S	Arsenal St.	Brighton	60	3,600	26	100	24,000	21
729S	Eliot Bridge	Cambridge	<10	3,500	14	10	20,000	20
743S	Western Ave.	Cambridge	30	5,500	27	30	2,200	21
763S	Mass. Ave. at Harvard Bridge	Boston	10	3,800	26	10	30,000	22
773S	Longfellow Bridge	Boston	<10	4,600	14	10	11,000	20
784S	New Charles River Dam	Boston	10	8,150	28	10	1,700	23
EPA 2002-2003								
CRBL03	Daly Park	Boston	48	694	9			
CRBL04	Herter East Park	Boston	4	1,100	8			
CRBL05	Magazine Beach	Boston	44	2,400	12	330	1,099	4
CRBL06	Downstream Boston University Bridge	Boston	12	874	12	128	1,500	4
CRBL07	Downstream Stony Bk & Mass. Ave	Boston	4	315	12	8	56	4
CRBLA8	Off the Esplanade	Boston	<4	208	12	4	28	4
CRBL09	Upstream Longfellow Bridge	Boston	<4	76	12	8	100	4
CRBL10	Community Boating Area	Boston	4	50	9			
CRBL11	Between Longfellow Bridge & Old Dam	Boston	<4	52	12	12	44	4
CRBL12	Upstream of Railroad Bridge	Boston	8	360	9			
USGS 1999-2000 (mean min & max reported for wet weather)								
01104710	Charles River at Science Museum	Boston	<10	100	13	<10	200	6
MADEP WQA 1997-1998								
CR00	100 ft. Downstream of Watertown Dam	Watertown	200	500	2	920	1,800	2

Figures 4-1 and 4-2 provide a graphical representation of EPA fecal coliform data collected from 1998-2003, including stations CRBL03 through CRBL12 summarized in the Table 4-19, as part of the Clean Charles 2005 Initiative. Figure 4-3 provides a summary of the *E. coli* data collected in 2003 by the EPA for the Lower Charles River. A map showing sample locations for the EPA Clean Charles 2005 Water Quality Report is provided in Figure 4-4. Descriptions of sampling stations can be found in the Clean Charles 2005 Water Quality Report available for download at http://www.epa.gov/boston/charles/2005.html.

Thirty five percent of the fecal coliform samples collected as part of the EPA Core Monitoring Program exceeded the Class B WQS of 200 colonies/100 mL in 2003, compared to 31%, 35%, 23%, 8% and 17% in 2002, 2001, 2000, 1999 and 1998, respectively. Indicator bacteria levels are generally lower at downstream sample sites (Figure 4-2), where flow and water volume are also greater. The EPA Core Monitoring 2003 downstream dry weather fecal coliform samples exceeded the Class B WQS 9% of the time (stations CRBL01 – CRBL12), whereas upstream numbers exceeded the Class B WQS 76% of the time. *E. coli* numbers in 2003 (Figure 4-3) displayed the same pattern as fecal coliform (lower numbers near the mouth of the Charles River).

Boxplots of the MWRA 1998-2001 data are provided in Figures 4-5 (fecal coliform data) and 4-6 (enterococci data). A sample location map is provided in Figure 4-7. Sample location descriptions for the MWRA data can be found in Appendix A of this report.

A similar trend with lower bacteria numbers further downstream was observed in data collected by the MWRA (Figure 4-5). Median fecal coliform values for upstream stations exceeded the Class B WQS under all weather conditions, but median values for downstream stations (008, 009, 010, 166, and 011), although elevated, generally meet this standard. Upstream enterococci median values failed to meet the MADPH bathing beach standard during all weather conditions. Median values for the downstream stations were able to meet the MADPH standard during dry weather, but most of these stations exceeded the standard under wet weather conditions.

Figure 4-1. Fecal Coliform Data from 1998-2003 (modified Figure 1 from USEPA 2004b).

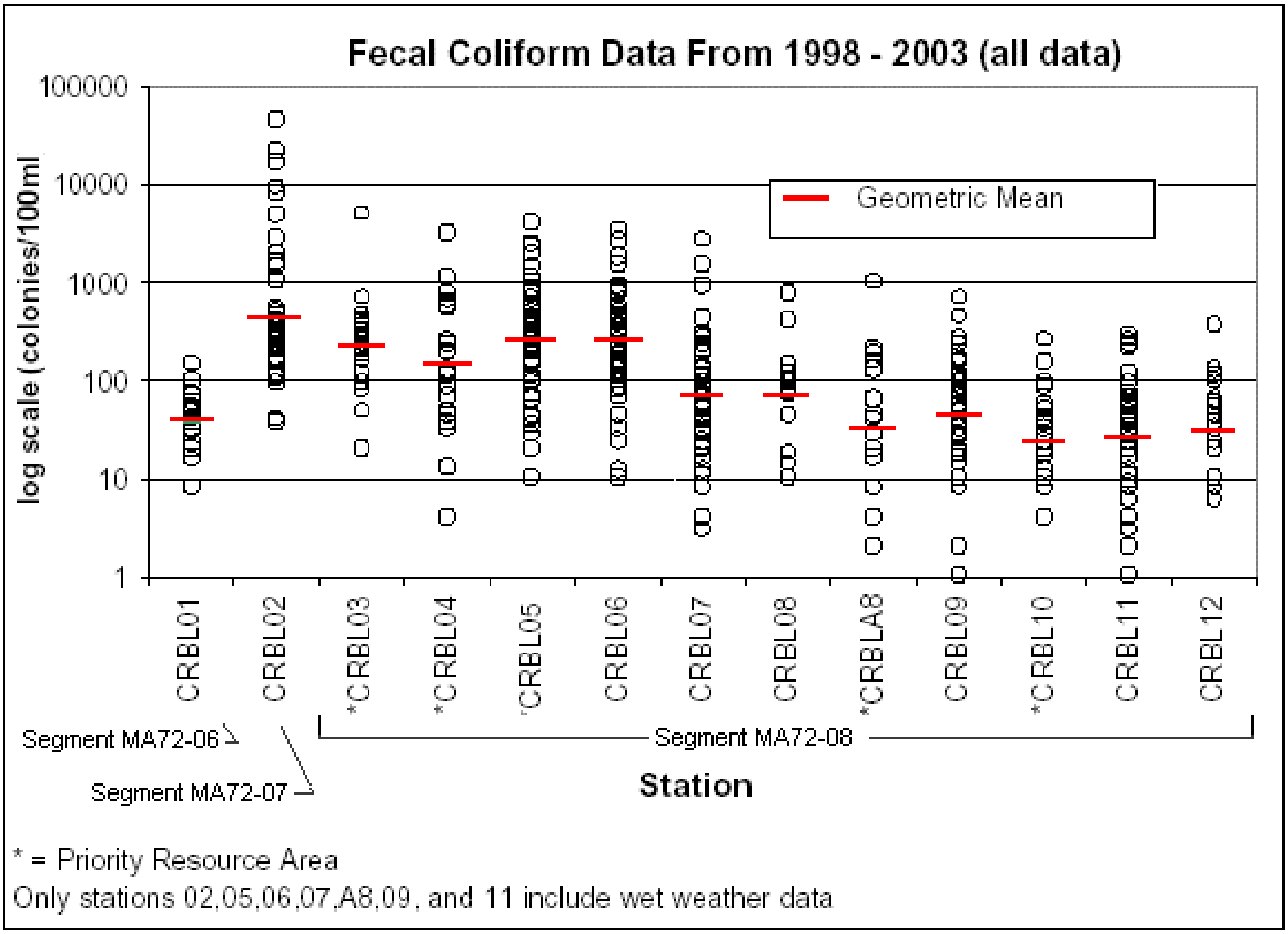


Figure 4-2. Fecal Coliform Dry Weather Geometric Means (modified Figure 2a from USEPA 2004b).

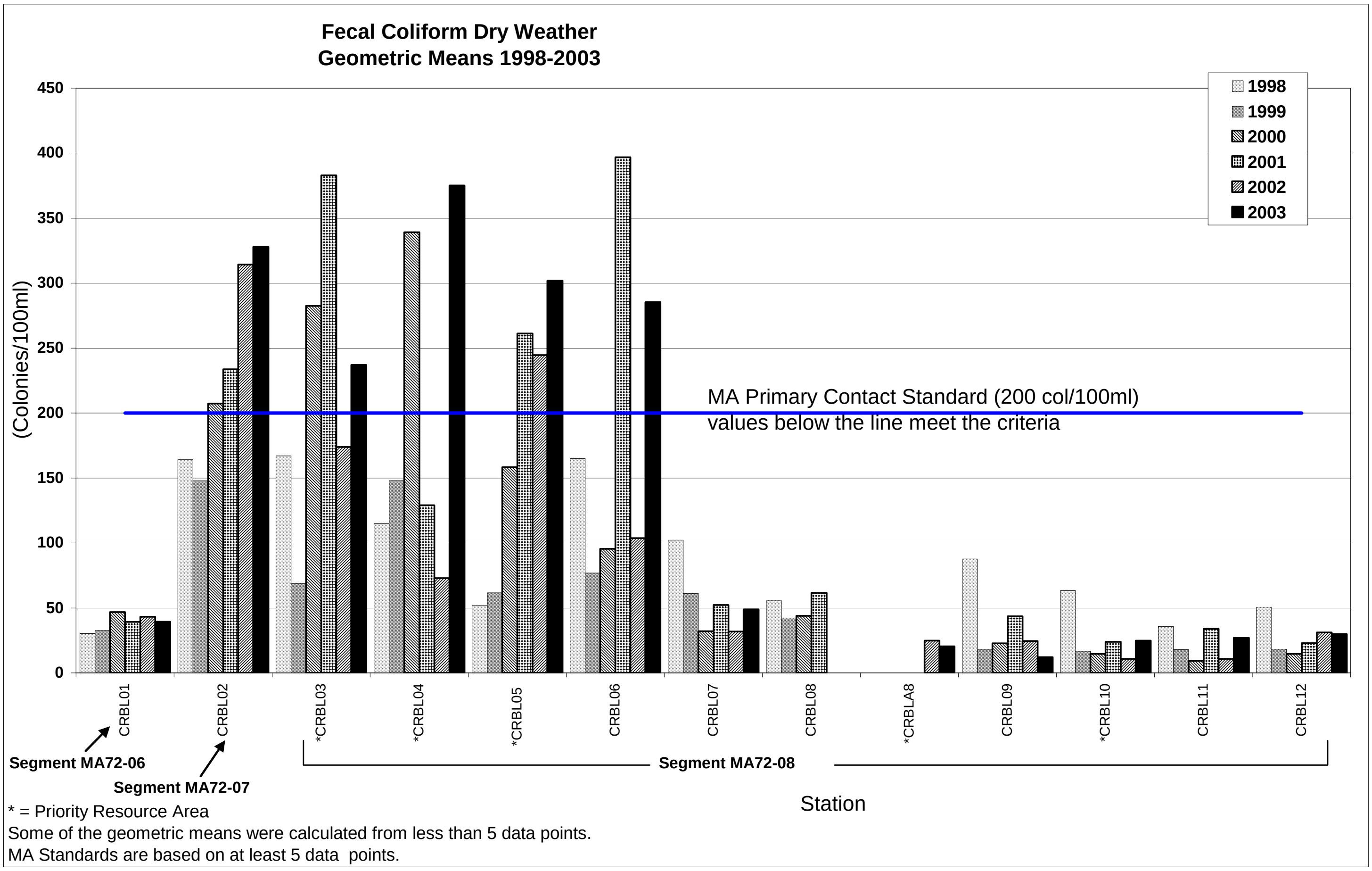


Figure 4-3. 2003 *E. coli* Counts in the Lower Charles River (modified Figure 3a from USEPA 2004b).

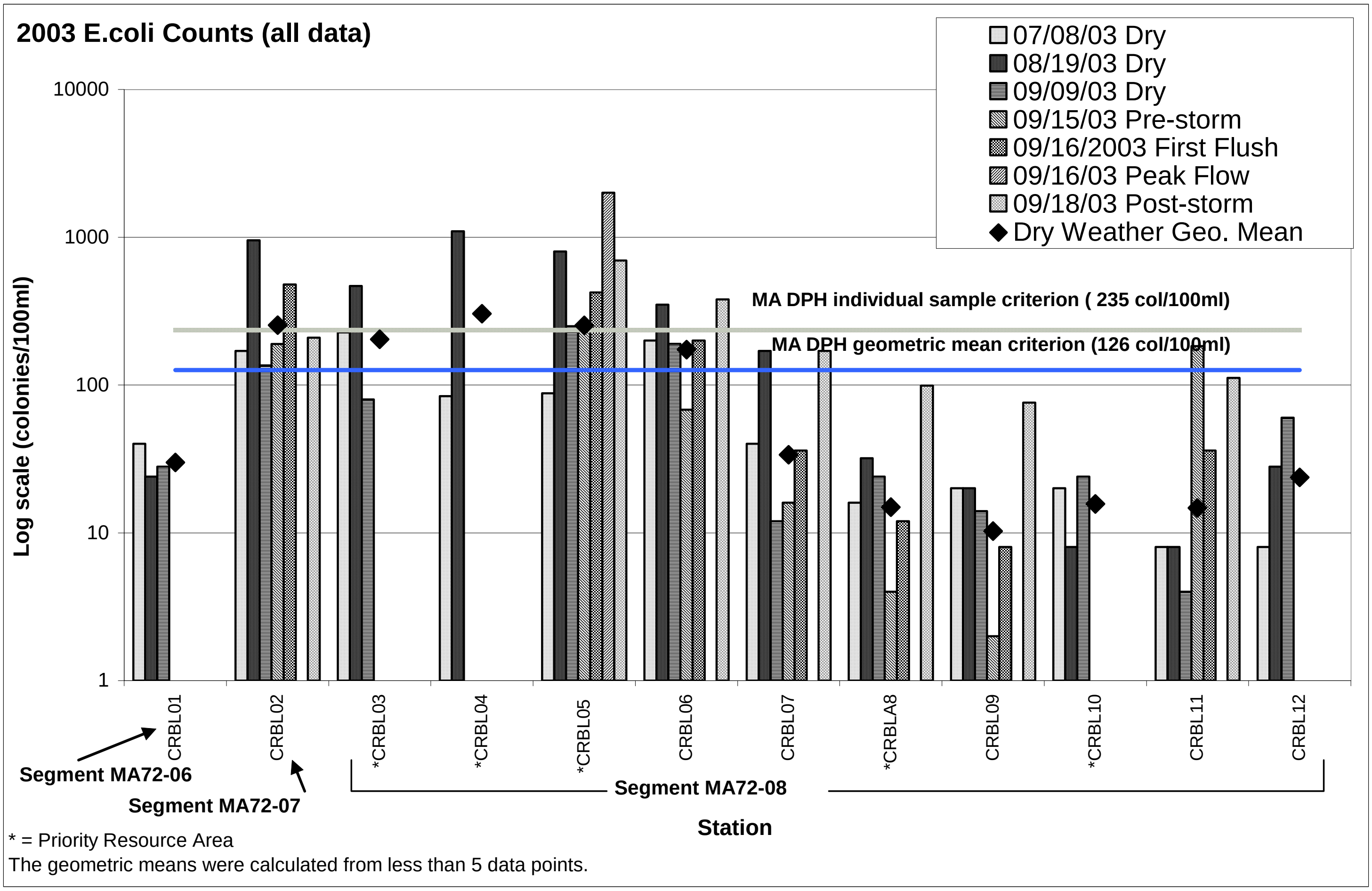


Figure 4-4. USEPA Core Monitoring Locations and Priority Resource Areas.

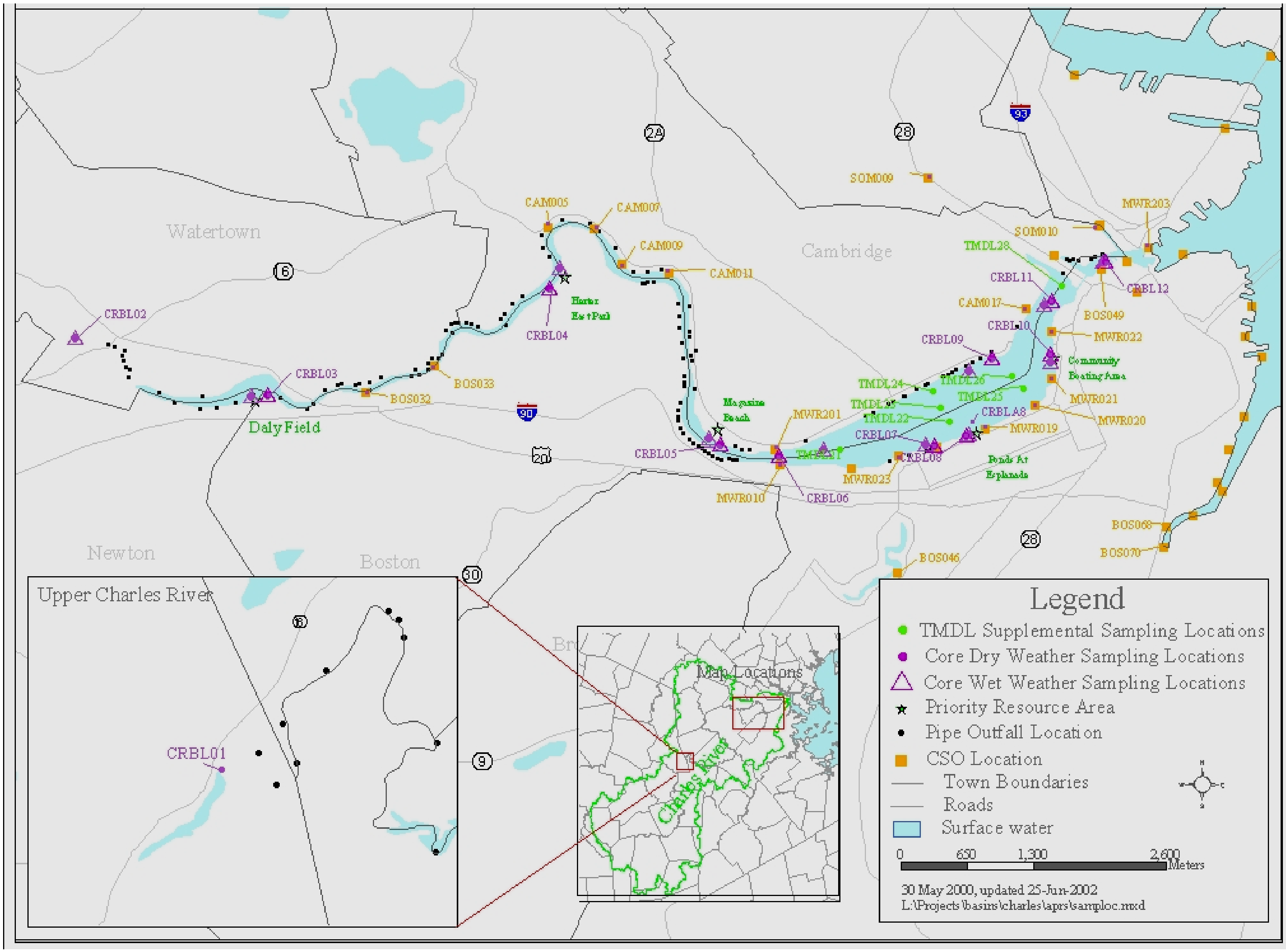


Figure 4-5. Lower Charles River Fecal Coliform Results 1998-2001 (modified from Coughlin 2003).

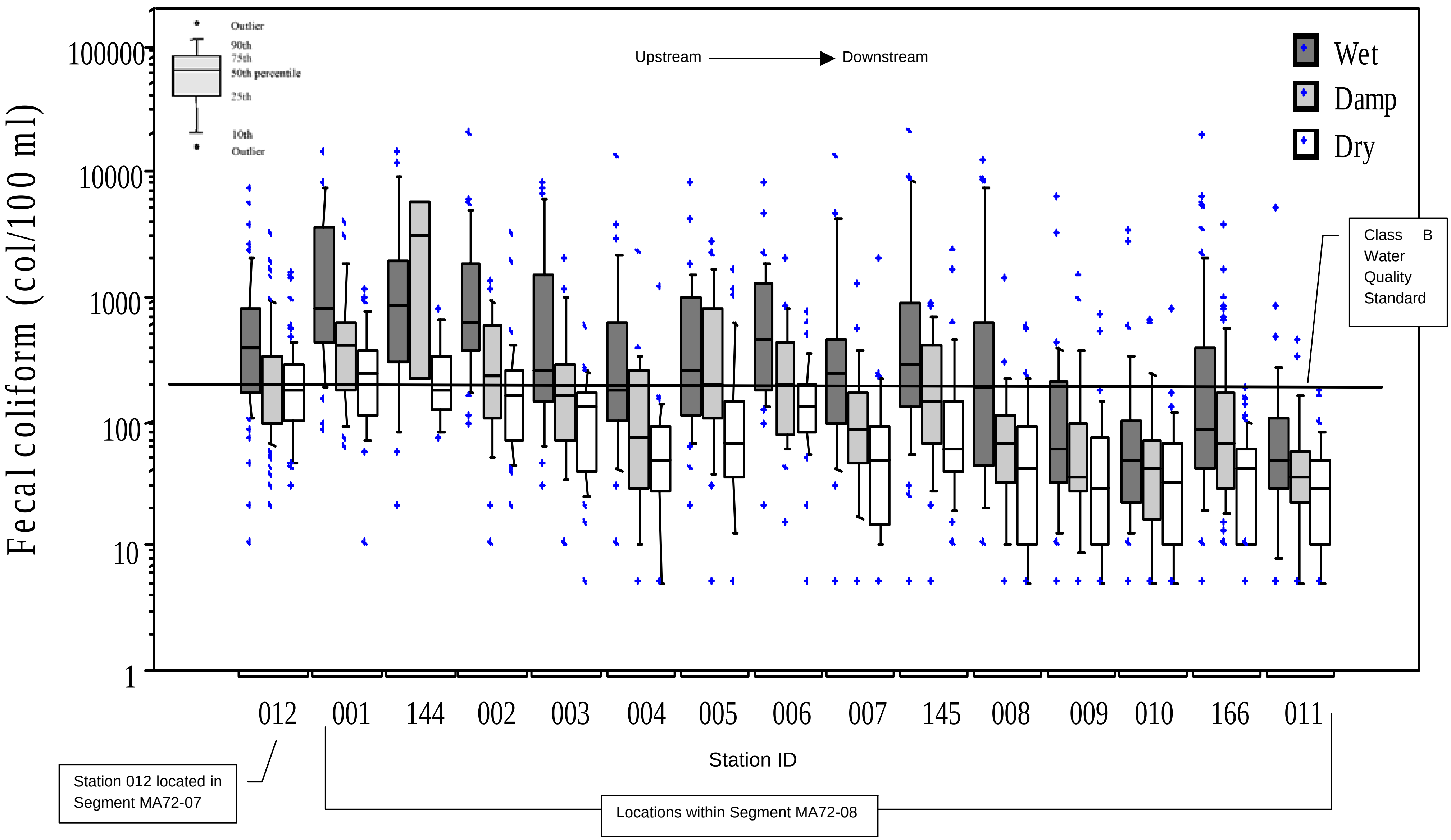


Figure 4-6. Lower Charles River Enterococci Results 1998-2001 (modified from Coughlin 2003).

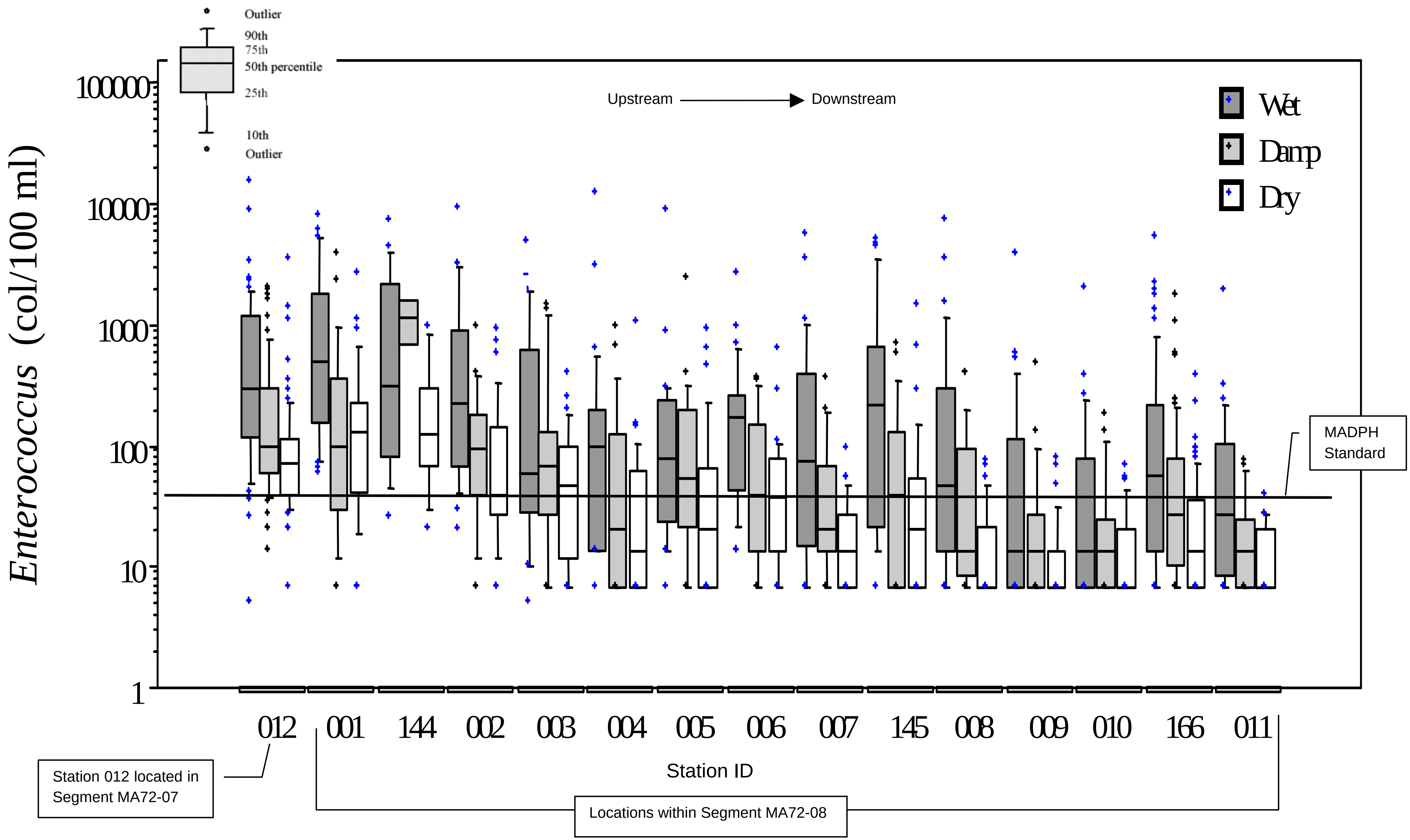
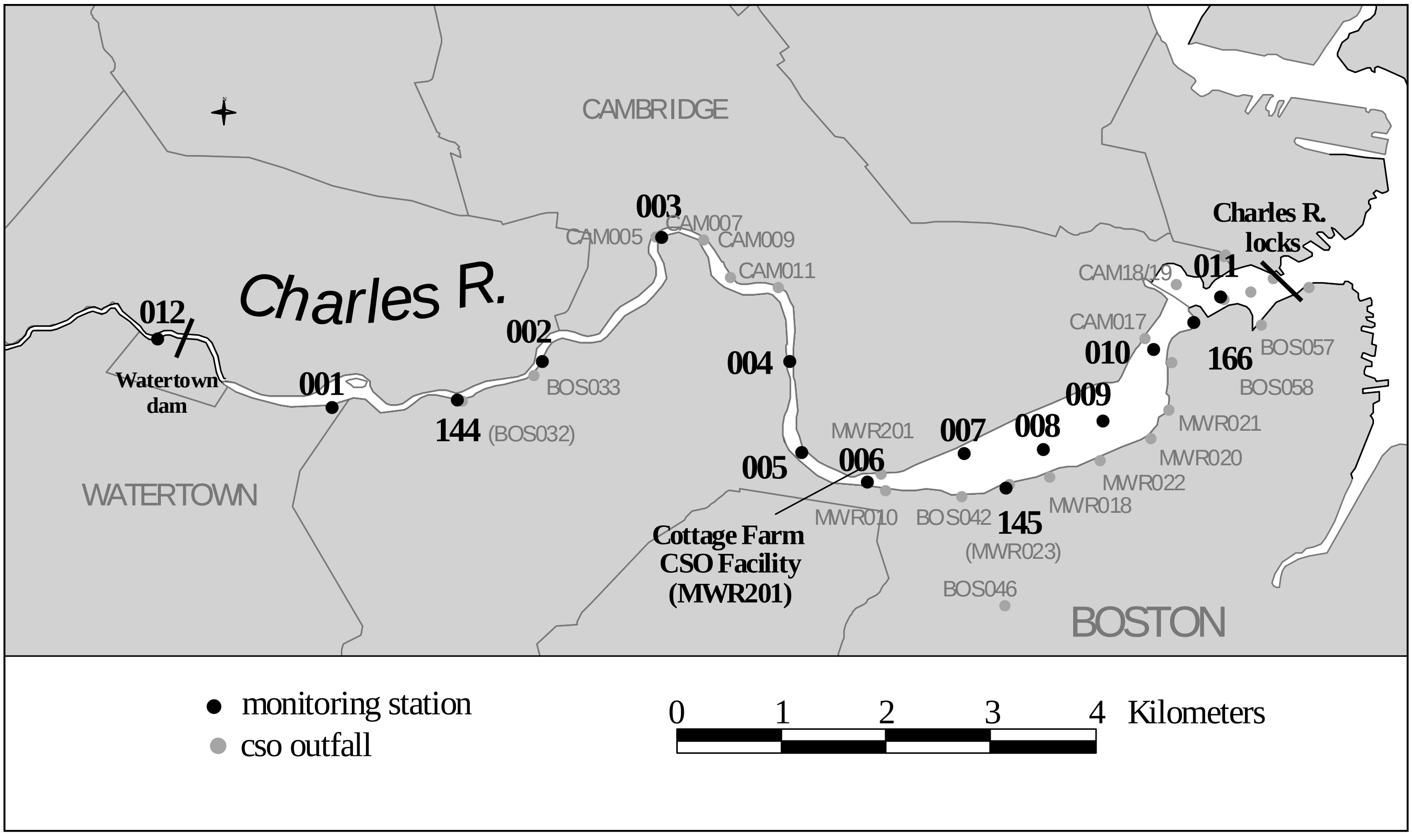


Figure 4-7. MWRA Sample Location Map (Coughlin 2003).



Unnamed Tributary Segment MA72-30

This segment is a 0.1 mile long Class B waterbody. This unnamed tributary, locally known as Laundry Brook, is located in Watertown and extends from California Street and flows north to the Charles River. There are no known NPDES discharges or water withdrawals in this segment. See MADEP WQA for more information regarding this segment, available for download at http://www.mass.gov/dep/brp/wm/wqassess.htm.

USGS (June 1999 – September 2000) and MADEP WQA (July 1997 – April 1998) fecal coliform data for this segment are summarized in Table 4-20.

Table 4-20. MA72-30 Unnamed Tributary Fecal Coliform Data Summary

			Dry Weather (CFU/100 mL)			Wet Weather (CFU/100 mL)		
Site #	Description	Town	Min	Max	n	Min	Max	n
USGS 1999-2000 (mean, min & max reported for wet weather)								
01104640	Mouth of Laundry Brook	Watertown	50	5,500	13	1,200	44,000	9
MADEP WQA 1997-1998								
LB01	California St. (Laundry Bk)	Watertown	20	2,600	6	270	5,500	2

Unnamed Tributary Segment MA72-32

This segment is 0.5 miles and is not listed in the MADEP WQA. It is assumed Class B waterbody. This unnamed tributary, locally known as Sawins Brook, is located in Watertown and flows southeast from Elm Street to the Charles River. There are two former CSO outfalls along this tributary (MWRA 2003-02). Status of NPDES discharges, water withdrawals or water quality sampling data in this segment are unknown. There were no known fecal coliform data available for this segment at the time of this report.

Muddy River Segment MA72-11

This segment is a 4.2 mile long Class B warm water fishery. This impaired segment is a tributary to the Charles River beginning from Olmstead Park in Boston. There are four NPDES discharges in this drainage area and one CSO. The location of the CSO is provided on the MWRA map in Appendix A. See MADEP WQA for more information regarding this segment, available for download at http://www.mass.gov/dep/brp/wm/wqassess.htm.

USGS (June 1999 – September 2000) fecal coliform data for this segment are summarized in Table 4-21.

Table 4-21. MA72-11 Muddy River Fecal Coliform Data Summary.

			Dry Weather (CFU/100 mL)			Wet Weather (CFU/100 mL)		
Site #	Description	Town	Min	Max	n	Min	Max	n
USGS 1999-2000 (mean, min & max reported for wet weather)								
01104683	Mouth of Muddy River	Boston	<10	4,200	12	3,100	38,000	9

5.0 Potential Sources

The Charles River Watershed has 20 segments, located throughout the watershed, that are listed as pathogen impaired requiring a TMDL. These segments represent 80.4% of the river miles assessed. Sources of indicator bacteria in the Charles River Watershed are many and varied. A significant amount of work has been done in the last decade to improve the water quality in the Charles River Watershed.

Largely through the efforts of the CRWA, the Boston Water and Sewer Commission (BWSC), MWRA, EPA and MADEP field staff, numerous point and non-point sources of fecal contamination have been identified. Table 5-1 summarizes the river segments impaired due to measured indicator bacteria densities and identifies some of the suspected and known sources described in past literature.

Some dry weather sources include:

- agriculture,
- leaking sewer pipes,
- storm water drainage systems (illicit connections of sanitary sewers to storm drains),
- failing septic systems,
- recreational activities, and
- wildlife, including birds.

Some wet weather sources include:

- wildlife and domesticated animals (including pets),
- storm water runoff including municipal separate storm sewer systems (MS4),
- combined sewer overflows (CSOs), and
- sanitary sewer overflows (SSOs).

It is difficult to provide accurate quantitative estimates of indicator bacteria contributions from the various sources in the Charles River Watershed because many of the sources are diffuse and intermittent, and extremely difficult to monitor or accurately model. Therefore, a general level of quantification according to source category is provided (e.g., see Tables 5-2 and 5-3). This approach is suitable for the TMDL analysis because it indicates the magnitude of the sources and illustrates the need for controlling them. Additionally, many of the sources (failing septic systems, leaking sewer pipes, sanitary sewer overflows, and illicit sanitary sewer connections) are prohibited, because they indicate a potential health risk and, therefore, must be eliminated. However, estimating the magnitude of overall indicator bacteria loading (the sum of all contributing sources) is achieved for wet and dry conditions using the extensive ambient data available that define baseline conditions (see segment summary tables and WQA).

Table 5-1. Some of the Potential Sources of Bacteria in Pathogen Impaired Segments in the Charles River Basin.

Segment	Potential Sources
MA72-01 Charles River	Unknown
MA72-02 Charles River	Illicit sewer discharge to the storm drain at Central St and Godfrey Brk
MA72-03 Charles River	Unknown
MA72-04 Charles River	Unknown
MA72-05 Charles River	Unknown
MA72-10 Stop River	Unknown
MA72-16 Bogastow River	Tributary (Dopping Brook)
MA72-06 Charles River	Storm water; agricultural inputs; Waban and Fuller Brks
MA72-18 Fuller Brook	Waterfowl in pond discharging to unnamed tributary; storm water
MA72-07 Charles River	Storm water; illicit sewer discharge; tributaries; waterfowl
MA72-21 Rock Meadow Brook	Unknown
MA72-23 Sawmill Brook	Illicit sewer discharge to the storm drain located in St. Joseph's Cemetery
MA72-24 South Meadow Brook	Illicit sewer discharge to the storm drain and/or failing infrastructure
MA72-25 Rosemary Brook	Waterfowl; other unknown sources
MA72-28 Beaver Brook	Storm water; illicit sewer discharge
MA72-29 Cheese Cake Brook	Illicit sewer discharge to storm drain located upstream from Watertown St.; Additional illicit sewer discharges
MA72-08 Charles River	CSOs; urban runoff; storm drains; illicit sewer connections
MA72-30 Unnamed Tributary	Illicit sewer discharges
MA72-32 Unnamed Tributary	Unknown
MA72-11 Muddy River	Sewer cross connections (Daisy Field, Tannery Brk, Village Brk and Longwood Ave); Storm water; illicit sewer connections

MS4 = Municipal Separate Storm Water Sewer System – community storm water drainage system
Most sources were identified in the MADEP WQA, although some sources have been identified by other organizations such as USGS, MWRA and CRWA.

Agriculture

Land used primarily for agriculture is likely to be impacted by a number of activities that can contribute to indicator bacteria impairments of surface waters. Activities with the potential to contribute to high indicator bacteria concentrations include:

- Field application of manure,
- Runoff from grazing areas,
- Direct deposition from livestock in streams,
- Animal feeding operations,
- Leaking manure storage facilities, and
- Runoff from barnyards.

Indicator bacteria numbers are generally associated with sediment loading. Reducing sediment loading often results in a reduction of indicator bacteria loading as well. Brief summaries of some of these techniques are provided in the "*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*".

Sanitary Waste

Leaking sewer pipes, illicit sewer connections, sanitary sewer overflows (SSOs), combined sewer overflows (CSOs) and failing septic systems represent a direct threat to public health since they result in discharge of partially treated or untreated human wastes to the surrounding environment. Quantifying these sources is extremely speculative without direct monitoring of the source because the magnitude is directly proportional to the volume of the source and its proximity to the surface water. Typical values of fecal coliform in untreated domestic wastewater range from 10^4 to 10^6 MPN/100mL (Metcalf and Eddy 1991).

Illicit sewer connections into storm drains result in direct discharges of sewage via the storm drainage system outfalls. The existence of illicit sewer connections to storm drains is well documented in many urban drainage systems, particularly older systems that may have once been combined. The CRWA, USGS, EPA, MWRA and the Boston Water and Sewer Commission (BWSC) and many towns in the Charles River Watershed have been active in the identification and mitigation of these sources. It is estimated by EPA New England that over one million gallons per day (gpd) of illicit discharges were removed in the last decade in the greater Boston area. Additionally, CSO discharges have decreased due to the MWRA CSO Control Plan (MWRA 2004) and capacity has increased at the Deer Island Treatment Plant. It is probable that numerous other illicit sewer connections exist in storm drainage systems serving the older developed portions of the basin.

Monitoring of storm drain outfalls during dry weather is needed to document the presence or absence of sewage in the drainage systems. The majority of the Charles River Watershed (75.6%) is classified as Urban Areas by the United States Census Bureau and is therefore subject to the Stormwater Phase II Final Rule that requires the development and implementation of an illicit discharge detection and elimination plan. See Section 7.0 of this TMDL for information regarding illicit discharge detection guidance.

Septic systems designed, installed, operated and maintained in accordance with 310 CMR 15.000: Title 5, are not significant sources of fecal coliform bacteria. Studies demonstrate that wastewater located four feet below properly functioning septic systems contain on average less than one fecal coliform bacteria organism per 100 mL (Ayres Associates 1993). Failed or non-conforming septic systems, however, can be a major contributor of fecal coliform to the Charles River and tributaries. Wastes from failing septic systems enter surface waters either as direct overland flow or via groundwater. Wet weather events typically increase the rate of transport of pollutant loadings from failing septic systems to surface waters because of the wash-off effect from runoff and the increased rate of groundwater recharge.

Recreational use of waterbodies is a source of pathogen contamination. Swimmers themselves may contribute to pathogen impairment at swimming areas. When swimmers enter the water, residual fecal matter may be washed from the body and contaminate the water with pathogens. In addition, small children in diapers may contribute to contamination of the recreational waters. These sources are likely to be particularly important when the number of swimmers is high and the flushing action of waves is low.

Wildlife and Pet Waste

Animals that are not pets can be a potential source of pathogens. Geese, gulls, and ducks are speculated to be a major pathogen source, particularly at lakes and storm water ponds where large resident populations have become established (Center for Watershed Protection 1999).

Household pets such as cats and dogs can be a substantial source of bacteria – as much as 23,000,000 colonies/gram, according to the Center for Watershed Protection (1999). A rule of thumb estimate for the number of dogs is ~1 dog per 10 people producing an estimated 0.5 pound of feces per dog per day. This translates to an estimated 90,000 dogs in the watershed producing 45,000 pounds of feces per day. Uncollected pet waste is then flushed from the parks, beaches and yards where pets are walked and transported into nearby waterways during wet-weather.

Storm Water

Storm water runoff is another significant contributor of pathogen pollution. As discussed above, during rain events fecal matter from domestic animals and wildlife are readily transported to surface waters via the storm water drainage systems and/or overland flow. The natural filtering capacity provided by vegetative cover and soils is dramatically reduced as urbanization occurs because of the increase in impervious areas (i.e., streets, parking lots, etc.) and stream channelization in the watershed.

Extensive storm water data have been collected and compiled both locally and nationally (e.g., Tables 4-1, 4-2, 5-2 and 5-3) in an attempt to characterize the quality of storm water. Bacteria are easily the most variable of storm water pollutants, with concentrations often varying by factors of 10 to 100 during a single storm. Considering this variability, storm water bacteria concentrations are difficult to accurately predict. Caution must be exercised when using values from single wet weather grab samples to estimate the magnitude of bacteria loading because it is often unknown whether the sample is representative of the "true" mean. To gain an understanding of the magnitude of bacterial loading from storm water and avoid overestimating or underestimating bacteria loading, event mean concentrations (EMC) are often used. An EMC is the concentration of a flow proportioned sample throughout a storm event. These samples are commonly collected using an automated sampler which can proportion sample aliquots based on flow. Typical storm water event mean densities for various indicator bacteria in the Lower Charles River and nationwide are provided in Tables 5-2 and 5-3. These EMCs illustrate that storm water indicator bacteria concentrations from certain land uses (i.e., residential) are typically at levels sufficient to cause water quality problems.

The USGS water quality assessment stated "The failure of samples from most of the water-quality stations in this study to meet the minimum water-quality standards necessary to support swimming and boating after rainstorms strongly indicate sources such as urban runoff, illicit sewage discharges, and CSOs" (USGS 2002b). Figure 6 from "*Measured and Simulated Runoff to the Lower Charles River, Massachusetts, October 1999–September 2000*" (USGS 2002b) illustrates the numerous storm water discharge outfalls located within the Lower Charles River and is provided in Appendix A of this report.

Table 5-2. Lower Charles River Basin Storm Water Event Mean Bacteria Concentrations (data summarized from USGS 2002a) and Necessary Reductions to Meet Class B WQS.

Land Use Category	Fecal Coliform EMC (CFU/100 mL)	Number of Events	Class B WQS[1]	Reduction to Meet WQS (%)
Single Family Residential	2,800 – 94,000	8	10% of the samples shall not exceed 400 organisms/ 100 mL	2,400 – 93,600 (85.7 – 99.6)
Multifamily Residential	2,200 – 31,000	8		1,800 – 30,600 (81.8 – 98.8)
Commercial	680 – 28,000	8		280 – 27,600 (41.2 - 98.6)

[1] Class B Standard: Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms. Used 400 to illustrate required reductions since a geometric mean of the samples were not provided.

Table 5-3. Storm Water Event Mean Fecal Coliform Concentrations (as reported in MADEP 2002; original data provided in Metcalf & Eddy, 1992) and Necessary Reductions to Meet Class B WQS.

Land Use Category	Fecal Coliform[1] Organisms / 100 mL	Class B WQS[2]	Reduction to Meet WQS (%)
Single Family Residential	37,000	10% of the samples shall not exceed 400 organisms/ 100 mL	36,600 (98.9)
Multifamily Residential	17,000		16,600 (97.6)
Commercial	16,000		15,600 (97.5)
Industrial	14,000		13,600 (97.1)

[1] Derived from NURP study event mean concentrations and nationwide pollutant buildup data (USEPA 1983).

[2] Class B Standard: Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms. Used 400 to illustrate required reductions since a geometric mean of the samples were not provided.

6.0 Pathogen TMDL Development

Section 303 (d) of the Federal Clean Water Act (CWA) requires states to place water bodies that do not meet the water quality standards on a list of impaired waterbodies. The most recent impairment list, *2002 List*, identifies 20 segments within the Charles River Watershed for use impairment caused by excessive indicator bacteria concentrations.

The CWA requires each state to establish Total Maximum Daily Loads (TMDLs) for listed waters and the pollutant contributing to the impairment(s). TMDLs determine the amount of a pollutant that a waterbody can safely assimilate without violating the water quality standards. Both point and non-point pollution sources are accounted for in a TMDL analysis. Point sources of pollution (those discharges from discrete pipes or conveyances) subject to NPDES permits receive a waste load allocation (WLA) specifying the amount of pollutant each point source can release to the waterbody. Non-point sources of pollution (all sources of pollution other than point) receive a load allocation (LA) specifying the amount of a pollutant that can be released to the waterbody by this source. In accordance with the CWA, a TMDL must account for seasonal variations and a margin of safety, which accounts for any lack of knowledge concerning the relationship between effluent limitations and water quality. Thus:

$$\text{TMDL} = \text{WLAs} + \text{LAs} + \text{Margin of Safety}$$

Where:

WLA = Waste Load Allocation which is the portion of the receiving water's loading capacity that is allocated to each existing and future point source of pollution.

LA = Load Allocation which is the portion of the receiving water's loading capacity that is allocated to each existing and future non-point source of pollution.

This TMDL uses an alternative standards-based approach which is based on indicator bacteria concentrations, but considers the terms of the above equation. This approach is more in line with the way bacterial pollution is regulated (i.e., according to concentration standards) and achieves essentially the same result as if the equation were to be used.

6.1. Indicator Bacteria TMDL

Loading Capacity

The pollutant loading that a waterbody can safely assimilate is expressed as either mass-per-time, toxicity or some other appropriate measure (40 CFR § 130.2). Typically, TMDLs are expressed as total maximum daily loads. Expressing the TMDL in terms of daily loads is difficult to interpret given the very high numbers of indicator bacteria and the magnitude of the allowable load is dependent on flow conditions and, therefore, will vary as flow rates change. For example, a very high load of indicator bacteria are allowable if the volume of water that transports indicator bacteria is also high. Conversely, a relatively low load of indicator bacteria may exceed water quality standard if flow rates are low. Therefore, the MADEP believes it is appropriate to express indicator bacteria TMDLs in terms of a concentration because the water quality standard is also expressed in terms of the concentration of organisms per 100 mL. Since source concentrations may not be directly added due to varying flow conditions, the TMDL equation is modified and reflects a margin of safety in the case of this pathogen concentration based TMDL. To ensure attainment with Massachusetts' WQS for indicator bacteria, all sources (at their point of discharge to the receiving water) must be equal to or less than the WQS for indicator organisms. For all the above reasons the TMDL is simply set equal to the concentration-based standard and may be expressed as follows:

$$\text{TMDL} = \text{State Standard} = \text{WLA}_{(p1)} = \text{LA}_{(n1)} = \text{WLA}_{(p2)} = \text{etc.}$$

Where:

$\text{WLA}_{(p1)}$ = allowable concentration for point source category (1)
$\text{LA}_{(n1)}$ = allowable concentration for nonpoint source category (1)
$\text{WLA}_{(p2)}$ = allowable concentration for point source category (2) etc.

For Class A surface waters (1) *the arithmetic mean of a representative set of fecal coliform samples shall not exceed 20 organisms per 100 mL*; and (2) *no more than 10% of the samples shall exceed 100 organisms per 100 mL.*

For Class B surface waters (1) *the geometric mean of a representative set of fecal coliform samples shall not exceed 200 organisms per 100 mL*; and (2) *no more than 10% of the samples shall exceed 400 organisms per 100 mL*.

For freshwater bathing beaches (MADPH standard, not yet adopted by the MADEP) (1) *the geometric mean of the most recent five enterococci levels within the same bathing season shall not exceed 33 colonies per 100 mL* and (2) *no single enterococci sample shall exceed 61 colonies per 100 mL*. – OR – (1) *the geometric mean of the most recent five E. coli levels within the same bathing season shall not exceed 126 colonies per 100 mL* and (2) *no single E. coli sample shall exceed 235 colonies per 100 mL.*

Waste Load Allocations (WLAs) and Load Allocations (LAs).

There are several WWTPs and other NPDES-permitted wastewater discharges within the Charles River Watershed. NPDES wastewater discharge WLAs are set at the WQS. In addition there are numerous storm water discharges from storm drainage systems throughout the watershed. All piped discharges are, by definition, point sources regardless of whether they are currently subject to the requirements of NPDES permits. Therefore, a WLA set equal to the WQS will be assigned to the portion of the storm water that discharges to surface waters via storm drains.

WLAs and LAs are identified for all known source categories including both dry and wet weather sources for Class A and Class B segments within the Charles River Watershed. Establishing WLAs and LAs that only address dry weather indicator bacteria sources would not ensure attainment of standards because of the significant contribution of wet weather indicator bacteria sources to WQS exceedances. Illicit sewer connections and deteriorating sewers leaking to storm drainage systems represent the primary dry weather point sources of indicator bacteria, while failing septic systems and possibly leaking sewer lines represent the non-point sources. Wet weather point sources include discharges from storm water drainage systems (including MS4s), sanitary sewer overflows (SSOs) and combined sewer overflows (CSOs). Wet weather non-point sources primarily include diffuse storm water runoff.

Table 6-1 presents the indicator bacteria WLAs and LAs for the various source categories. WLAs and LAs will change to reflect the revised indicator organisms (*E. coli* and enterococci) when the updated WQS have been finalized (See Section 3.0 of this report). Source categories representing discharges of untreated sanitary sewage to receiving waters are prohibited, and therefore, assigned WLAs and LAs equal to zero. There are three sets of WLAs and LAs: Class A waters, Class B waters, and Freshwater Beaches.

The TMDL should provide a discussion of the magnitudes of the pollutant reductions needed to attain the goals of the TMDL. Since accurate estimates of existing sources are generally unavailable, it is difficult to estimate the pollutant reductions for specific sources. For the illicit sources including failing septic systems, the goal is complete elimination (100% reduction). However, overall wet weather indicator bacteria load reductions can be estimated using typical storm water bacteria concentrations, as presented in the *Charles River Basin Watershed 1997/1998 Water Quality Assessment Report* and additional data reports from the USGS, MADEP, EPA and MWRA (see Section 4.0 of this report for data resources). These data indicate that up to two to three orders of magnitude (i.e., greater than 90%) reductions in storm water fecal coliform loadings generally will be necessary, especially in developed areas. This goal is expected to be accomplished through implementation of the best management practices (BMPs) associated with the Phase II control program in designated Urban Areas. The specific goal for controlling discharges from combined sewer overflows (CSOs) will be based on the site specific studies embodied in the Long Term Control Plan being developed by each community with combined sewers.

The expectation to attain WQS at the point of discharge is environmentally protective, and offers a practical means to identify and evaluate the effectiveness of control measures. In addition, this approach establishes clear objectives that can be easily understood by the public and individuals responsible for monitoring activities.

This TMDL applies to the 20 pathogen impaired segments of the Charles River Watershed that are currently listed on the CWA § 303(d) list of impaired waters. MADEP recommends however, that the information contained in this TMDL guide management activities for all other waters throughout the watershed to help maintain and protect existing water quality. For these non-impaired waters, Massachusetts is proposing “pollution prevention TMDLs” consistent with CWA § 303(d)(3).

The analyses conducted for the pathogen impaired segments in this TMDL would apply to the non-impaired segments, since the sources and their characteristics are equivalent. The waste load and/or load allocation for each source and designated use would be the same as specified herein. Therefore, the pollution prevention TMDLs would have identical waste load and load allocations based on the sources present and the designated use of the water body segment (see Table ES-1 and Table 6-1).

Table 6-1. Indicator Bacteria Waste Load Allocations (WLAs) and Load Allocations (LAs) for the Charles River Basin.

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL)[1]	Load Allocation Indicator Bacteria (CFU/100 mL)[1]
A & B	Illicit discharges to storm drains	0	N/A
A & B	Leaking sanitary sewer lines	0	N/A
A & B	Failing septic systems	N/A	0
A	NPDES – WWTP	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples, nor shall 10% of the samples exceed 100 organisms[2]	N/A
A	Storm water runoff Phase I and II	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples, nor shall 10% of the samples exceed 100 organisms[3]	N/A
A	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples, nor shall 10% of the samples exceed 100 organisms[3]
B	CSOs	Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[4]	N/A
B	NPDES – WWTP	Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[2]	N/A
B	Storm water runoff Phase I and II	Not to exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[3]	N/A
B	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[3]

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL)[1]	Load Allocation Indicator Bacteria (CFU/100 mL)[1]
Fresh Water Beaches[5]	All Sources	Enterococci not to exceed a geometric mean of 33 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 61 colonies OR *E. coli* not to exceed a geometric mean of 126 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 235 colonies	Enterococci not to exceed a geometric mean of 33 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 61 colonies OR *E. coli* not to exceed a geometric mean of 126 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 235 colonies

N/A means not applicable

[1] Waste Load Allocation (WLA) and Load Allocation (LA) refer to fecal coliform densities unless specified in table.

[2] Or shall be consistent with the Waste Water Treatment Plant (WWTP) National Pollutant Discharge Elimination System (NPDES) permit.

[3]The expectation for WLAs and LAs for storm water discharges is that they will be achieved through the implementation of BMPs and other controls.

[4] Or shall be consistent with an approved Long Term Control Plan (LTCP) for Combined Sewer Overflow (CSO) abatement. If the level of control specified in the LTCP is less than what is necessary to attain Class B water quality standards, then the above criteria apply unless MADEP has proposed and EPA has approved water quality standards revisions for the receiving water.

[5] Massachusetts Department of Public Health regulations (105 CMR Section 445)

Note: this table represents waste load and load reductions based on water quality standards current as of the publication date of these TMDLs, any future changes made to the Massachusetts water quality standards will become the governing water quality standards for these TMDLs.

This Charles River Watershed TMDL may, in appropriate circumstances, also apply to segments that are listed for pathogen impairment in subsequent Massachusetts CWA § 303(d) Integrated List of Waters. For such segments, this TMDL may apply if, after listing the waters for pathogen impairment and taking into account all relevant comments submitted on the CWA § 303(d) list, the Commonwealth determines with EPA approval of the CWA § 303(d) list that this TMDL should apply to future pathogen impaired segments.

6.2. Margin of Safety

This section addresses the incorporation of a Margin of Safety (MOS) in the TMDL analysis. The MOS accounts for any uncertainty or lack of knowledge concerning the relationship between pollutant loading and water quality. The MOS can either be implicit (i.e., incorporated into the TMDL analysis through conservative assumptions) or explicit (i.e., expressed in the TMDL as a portion of the loadings). This TMDL uses an implicit MOS, through inclusion of two conservative assumptions. First, the TMDL does not account for mixing in the receiving waters and assumes that zero dilution is available. Realistically, influent water will mix with the receiving water and become diluted below the water quality standard, provided that the receiving water concentration does not exceed the TMDL concentration. Second, the goal of attaining standards at the point of discharge does not account for losses due to die-off and settling of indicator bacteria that are known to occur.

6.3. Seasonal Variability

In addition to a Margin of Safety, TMDLs must also account for seasonal variability. Pathogen sources to Charles River waters arise from a mixture of continuous and wet-weather driven sources, and there may be no single critical condition that is protective for all other conditions. This TMDL has set WLAs and LAs for all known and suspected source categories equal to the Massachusetts WQS independent of seasonal and climatic conditions. This will ensure the attainment of water quality standards regardless of seasonal and climatic conditions. Controls that are necessary will be in place throughout the year, protecting water quality at all times. However, for discharges that do not affect shellfish beds, intakes for water supplies and primary contact recreation is not taking place (i.e., during the winter months) seasonal disinfection is permitted for NPDES point source discharges.

7.0 Implementation Plan

Setting and achieving TMDLs should be an iterative process, with realistic goals over a reasonable timeframe and adjusted as warranted based on ongoing monitoring. The concentrations set out in the TMDL represent reductions that will require substantial time and financial commitment to be attained. A comprehensive control strategy is needed to address the numerous and diverse sources of pathogens in the Charles River Watershed.

Controls on several types of pathogen sources will be required as part of the comprehensive control strategy. Many of the sources in the Charles River Watershed including sewer connections to drainage systems, leaking sewer pipes, sanitary sewer overflows, and failing septic systems, are prohibited and must be eliminated. Individual sources must be first identified in the field before they can be abated. Pinpointing sources typically requires extensive monitoring of the receiving waters, and tributary storm water drainage systems during both dry and wet weather conditions. A comprehensive program is needed to ensure illicit sources are identified and that appropriate actions will be taken to eliminate them. The MADEP, EPA, MWRA and the CRWA have been successful in carrying out such monitoring, identifying sources, and, in some cases mobilizing the responsible municipality and other entities to begin to take corrective actions.

Storm water runoff represents another major source of indicator bacteria to the Charles River and tributaries, and the current level of control is inadequate for standards to be attained. Improving storm water runoff quality is essential for restoring water quality and recreational uses. At a minimum, intensive application of non-structural BMPs is needed throughout the watershed to reduce pathogen loadings as well as loadings of other storm water pollutants (e.g., nutrients and sediments) contributing to use impairment in the Charles River Watershed. Depending on the degree of success of the non-structural storm water BMP program, structural controls may become necessary.

For these reasons, a basin-wide implementation strategy is recommended. The strategy includes a mandatory program for implementing storm water BMPs and eliminating illicit sources. The "*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*" was developed to support implementation of pathogen TMDLs. TMDL implementation-related tasks are shown in Table 7-1. The MADEP working with the CRWA, MWRA, EPA, BWSC and other team partners shall make every reasonable effort to assure implementation of this TMDL. These stakeholders can provide valuable assistance in defining hot spots and sources of pathogen contamination as well as the implementation of mitigation or preventative measures.

Table 7-1. Tasks

Task	Organization
Writing TMDL	MADEP
TMDL public meeting	MADEP
Response to public comment	MADEP
Organization, contacts with volunteer groups	MADEP/CRWA
Development of comprehensive storm water management programs including identification and implementation of BMPs	Charles River Basin Communities
Illicit discharge detection and elimination	Charles River Basin Communities with CRWA, MWRA and BWSC
Leaking sewer pipes and sanitary sewer overflows	Charles River Basin Communities
CSO management	MWRA/BWSC
Inspection and upgrade of on-site sewage disposal systems as needed	Homeowners, CRWA and Charles River Basin Communities (Boards of Health)
Organize implementation; work with stakeholders and local officials to identify remedial measures and potential funding sources	MADEP, CRWA and Charles River Basin Communities
Organize and implement education and outreach program	MADEP, CRWA and Charles River Basin Communities
Write grant and loan funding proposals	CRWA, Charles River Basin Communities and Planning Agencies with guidance from MADEP
Inclusion of TMDL recommendations in Executive Office of Environmental Affairs (EOEA) Watershed Action Plan	EOEA
Surface Water Monitoring	MADEP and CRWA
Provide periodic status reports on implementation of remedial activities	CRWA and MWRA

7.1. Summary of Activities within the Charles River Watershed

The CRWA has been active stewards of the watershed for 40 years. In that time the CRWA has:

- been actively involved with the development of Community Development Plans while emphasizing the growth impacts on the protection of natural resources,
- been a partner in the Earth Day Charles River Cleanup mobilizing over 1,000 volunteers,
- partnered with the USGS for data phase and modeling of nutrients in an effort to improve water quality management in the upper watershed,
- co-sponsored with the EPA conference on pathogen risks in recreational waters and provided outreach and education to schools and community groups,
- reviewed 30 building plans that have the potential to impact the Charles River and was able to institute changes to these plans to minimize pollution and to recharge aquifers,
- provided 80 volunteers to conduct and complete four years of monthly water quality monitoring,
- provided flag postings indicating bacteria conditions, where red flags indicate dangerous bacteria levels and blue flags indicate signal suitable conditions for boating over the past seven seasons,
- completed zoning plans for the Towns of Littleton and Holliston illustrating areas critical for aquifer recharge and showing potential impacts of development on water resources, and
- increased public appreciation of the Charles River through outreach and education, organizing an annual canoe and kayak race (Run of the Charles), and has published a waterproof pocket-sized Charles River Canoe and Kayak Guide with maps and access information.

The EPA Region I, together with federal, state, and local agencies and participation from citizens and watershed stewards including the CRWA, is striving to restore the Charles River so that it is fishable and swimmable by Earth Day 2005. This ambitious effort has utilized cutting edge technologies and strict law enforcement for the reduction or elimination of CSOs, illicit storm sewer connections, and other sources of pollutants to improve the water quality of the Charles River. "On May 2, 2003, EPA graded the river's water quality as a "B", the same grade as last year [2002] but a dramatic improvement from the "D" we gave the river seven years ago [1995]" (USEPA 2004c). In 2003, the CRWA received a $400,000 grant for continued cleanup efforts within the Charles River watershed. More information on the Charles River: Swimmable by 2005 program is provided on the EPA Region I website located at http://www.epa.gov/region1/charles/.

The BWSC, working together with the MWRA, has taken on a five year sewer separation project in the Charles River Watershed. The Stony Brook Sewer Separation Project will separate storm water from sanitary waste piping, eliminating discharge of untreated sewage into Stony Brook. Waste water will then be directed to MWRA Deer Island Waste Water Treatment Plant and storm water will discharge to the Muddy River, eventually discharging to the Charles River. More information regarding this project is available at the BWSC website located at http://www.bwsc.org/tab_menus/6frameset1.htm.

Significant improvements have been made in the Charles River Watershed; additional improvements are expected with implementation of new technology and additional controls. The "*Evaluation of Stormwater Management Benefits to the Lower Charles River*" (provided in Appendix B of this document) illustrates the "improvements in water quality in the Lower Charles River that have already been achieved and could be expected from the implementation of the CSO control plan developed by the Massachusetts Water Resources Authority (MWRA) and different levels of storm water control including illicit connection removal and Best Management Practices (BMPs)" (Metcalf and Eddy 2004). It has been estimated that the average percent exceedance of the Class B WSQ for fecal coliform has been reduced from 65% in 1995 to 34% in 2002. Additional improvements with implementation of a CSO recommended plan and basic storm water BMPs are predicted to result in an average percent exceedance of 20%, and an even lower predicted average percent exceedance with implementation of a CSO Recommended Plan and aggressive storm water BMPs of 7%.

Data supporting this TMDL indicate that indicator bacteria enter the Charles River from a number of contributing sources, under a variety of conditions. Activities that are currently ongoing and/or planned to ensure that the TMDL can be implemented include and are summarized in the following subsections. The "*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*" provides additional details on the implementation of pathogen control measures summarized below as well as additional measures not provided herein, such as by-law, ordinances and public outreach and education.

7.2. Agriculture

A number of techniques have been developed to reduce the contribution of agricultural activities to pathogen contamination. There are also many methods intended to reduce sediment loads from agricultural lands. Since bacteria are often associated with sediments, these techniques are also likely to result in a reduction in bacterial loads in run off as well. Brief summaries of some of these techniques are provided in the "*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*". Techniques generally include BMPs for field application of manure, animal feeding operations, barnyards, and managing animal grazing areas.

7.3. Illicit Sewer Connections, Failing Infrastructure and CSOs.

Elimination of illicit sewer connections, repairing failing infrastructure and controlling impacts associated with CSOs are of extreme importance. Several steps are currently underway in this regard. The CRWA, USGS, EPA, MWRA, BWSC and towns in the Charles River Watershed have been active in the identification and mitigation of these sources. "Between 1986, when the Commission's Illegal Sanitary Connection Remediation Program started and the end of 2004, a total of 931 illegal connections have been identified and 893 have been corrected. During 2004, the Commission's program removed an estimated 7,762 gallons per day of wastewater from the storm drainage system and receiving waters" (BWSC 2004). It is estimated by EPA New England that over one million gpd of illicit discharges were removed in the last decade. CSO discharges have decreased due to the MWRA CSO Control Plan (MWRA 2004). "To date, 21 CSO outlets have been closed [includes areas outside the Charles River Watershed], CSO volumes have been reduced by 70% and a minimum of 60% of the remaining flow is now treated" (MWRA 2004).

The MWRA developed a Three-Phase CSO Plan in 1994. Table 7-2 provides a summary of the planned activities (note: this plan includes CSOs discharging to other basins in addition to the Charles River). Details regarding CSO projects by community can be found at http://www.mwra.state.ma.us/03sewer/html/sewcso.htm.

Guidance for illicit discharge detection and elimination has been developed by EPA New England (USEPA 2004d). The guidance document provides a plan, available to all Commonwealth communities, to identify and eliminate illicit discharges (both dry and wet weather) to their separate storm sewer systems. Implementation of the protocol outlined in the guidance document satisfies the Illicit Discharge Detection and Elimination requirement of the NPDES program. A copy of the guidance document is provided in Appendix C.

Table 7-2. The MWRA CSO Plan: 1988 – 2008
(from http://www.mwra.state.ma.us/03sewer/html/sewcso.htm)

1988 — 1992	PHASE I	▪ Add CSO treatment facilities. ▪ Improve Deer Island Treatment Plant's ability to pump wet weather sewage flows.
	Results	▪ A reduction of CSO volume by 55% (over 1988 levels) ▪ Treatment of 50% of remaining CSO flows
1992 — 2000	PHASE 2	▪ Upgrade CSO treatment facilities ▪ Further increase the Deer Island Treatment Plant's ability to achieve full planned pumping and treatment capacity
	Results	▪ A reduction of CSO volume by 70% (over 1988 levels) ▪ Treatment of 60% of remaining CSO flows
1996 — 2008	PHASE 3	▪ Separate combined sewers in some areas ▪ Increase hydraulic capacity of the system in certain areas ▪ Screening/ disinfection/ dechlorination for Reserved Channel ▪ Construct storage facilities ▪ Upgrade CSO facilities to improve treatment performance
	Goals	▪ Close 36 of 84 CSOs ▪ Eliminate CSO discharges to swimming and shellfishing areas ▪ Reduce CSO volumes by 88% over 1988 levels ▪ Minimize untreated discharges ▪ Treat 95% of remaining flow

7.4. Storm Water Runoff

Storm water runoff can be categorized in two forms; 1) point source discharges and 2) non-point source discharges (includes sheet flow or direct runoff). Many point source storm water discharges are regulated under the NPDES Phase I and Phase II permitting programs when discharged to a Waters of the United States. Municipalities that operate regulated municipal separate storm sewer systems (MS4s) must develop and implement a storm water management plan (SWMP) which must employ, and set measurable goals for the following six minimum control measures:

1. public education and outreach particularly on the proper disposal of pet waste,
2. public participation/involvement,
3. illicit discharge detection and elimination,
4. construction site runoff control,
5. post construction runoff control, and
6. pollution prevention/good housekeeping.

Portions of towns in this watershed are classified as Urban Areas by the United States Census Bureau and are subject to the Stormwater Phase II Final Rule. This rule requires the development and implementation of an illicit discharge detection and elimination plan.

The NPDES permit does not, however, establish numeric effluent limitations for storm water discharges. Maximum extent practicable (MEP) is the statutory standard that establishes the level of pollutant reductions that regulated municipalities must achieve. The MEP standard is a narrative effluent limitation that is satisfied through implementation of SWMPs and achievement of measurable goals.

Non-point source discharges are generally characterized as sheetflow runoff and are not categorically regulated under the NPDES program and can be difficult to manage. However, some of the same principles for mitigating point source impacts may be applicable. Individual municipalities not regulated under the Phase I or II should implement the exact same six minimum control measures minimizing storm water contamination. The CRWA has been active in this regard, producing a plethora of literature for watershed protection and conservation, including a monthly email newsletter.

7.5. Failing Septic Systems

Septic system bacteria contributions to the Charles River and its tributaries may be reduced in the future through septic system maintenance and/or replacement. Additionally, the implementation of Title 5, which requires inspection of private sewage disposal systems before property ownership may be transferred, building expansions, or changes in use of properties, will aid in the discovery of poorly operating or failing systems. Because systems which fail must be repaired or upgraded, it is expected that the bacteria load from septic systems will be significantly reduced in the future. Regulatory and educational materials for septic system installation, maintenance and alternative technologies are provided by the MADEP on the worldwide web at http://www.mass.gov/dep/brp/wwm/t5pubs.htm.

7.6. Wastewater Treatment Plants

WWTP discharges are regulated under the NPDES program when the effluent is released to surface waters. Each WWTP has an effluent limit included in its NPDES or groundwater permit. Some NPDES permits are listed on the following website: www.epa.gov/region1/npdes/permits_listing_ma.html. Groundwater permits are available at http://www.mass.gov/dep/brp/gw/gwhome.htm.

7.7. Recreational Waters Use Management

Recreational waters receive pathogen inputs from swimmers. To reduce swimmers' contribution to pathogen impairment, shower facilities can be made available, and bathers should be encouraged to shower prior to swimming. In addition, parents should check and change young children's diapers when they are dirty.

7.8. Funding/Community Resources

A complete list of funding sources for implementation of non-point source pollution is provided in Section VII of the Massachusetts Nonpoint Source Management Plan Volume I (MADEP 2000b) available on line at http://www.mass.gov/dep/brp/wm/nonpoint.htm. This list includes specific programs available for non-point source management and resources available for communities to manage local growth and development. The State Revolving Fund (SRF) provides low interest loans to communities for certain capital costs associated with building or improving wastewater treatment facilities. In addition, many communities in Massachusetts sponsor low cost loans through the SRF for homeowners to repair or upgrade failing septic systems.

7.9. Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts

For a more complete discussion on ways to mitigate pathogen water pollution, see the "*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*" accompanying this document.

8.0 Monitoring Plan

The long term monitoring plan for the Charles River Watershed includes several components:

1. continue with the current monitoring of the Charles River Watershed (CRWA, MWRA, and EPA),
2. continue with MADEP watershed five-year cycle monitoring,
3. monitor areas within the watershed where data are lacking or absent to determine if the waterbody meets the use criteria,
4. monitor areas where BMPs and other control strategies have been implemented or discharges have been removed to assess the effectiveness of the modification or elimination,
5. assemble data collected by each monitoring entity to formulate a concise report where the basin is assessed as a whole and an evaluation of BMPs can be made, and
6. add/remove/modify BMPs as needed based on monitoring results.

The monitoring plan is an ever changing document that requires flexibility to add, change or delete sampling locations, sampling frequency, methods and analysis. At the minimum, all monitoring should be conducted with a focus on:

- capturing water quality conditions under varied weather conditions,
- establishing sampling locations in an effort to pin-point sources,
- researching new and proven technologies for separating human from animal bacteria sources, and
- assessing efficacy of BMPs.

9.0 Reasonable Assurances

Reasonable assurances that the TMDL will be implemented include both enforcement of current regulations, availability of financial incentives including low or no-interest loans to communities for wastewater treatment facilities through the State Revolving Fund (SRF), and the various local, state and federal programs for pollution control. Storm water NPDES permit coverage will address discharges from municipal owned storm water drainage systems. Enforcement of regulations controlling non-point discharges includes local enforcement of the states Wetlands Protection Act and Rivers Protection Act; Title 5 regulations for septic systems and various local regulations including zoning regulations. Financial incentives include Federal monies available under the CWA Section 319 NPS program and the CWA Section 604 and 104b programs, which are provided as part of the Performance Partnership Agreement between MADEP and the EPA. Additional financial incentives include state income tax credits for Title 5 upgrades, and low interest loans for Title 5 septic system upgrades through municipalities participating in this portion of the state revolving fund program.

10.0 Public Participation

To be added later….

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Appendix A

Select Data from: Summary of CSO Receiving Water Quality Monitoring in Boston Harbor and Tributary Rivers, 1989 – 2001 (Coughlin 2003), CSO Location Map from MWRA (MWRA 2004), and Outfalls to the Lower Charles River Map (USGS 2002)

Appendix B

Evaluation of Stormwater Management Benefits to the Lower Charles River
(Metcalf and Eddy 2004).

Appendix C

Lower Charles River Illicit Discharge Detection & Elimination (IDDE) Protocol
Guidance for Consideration - November 2004